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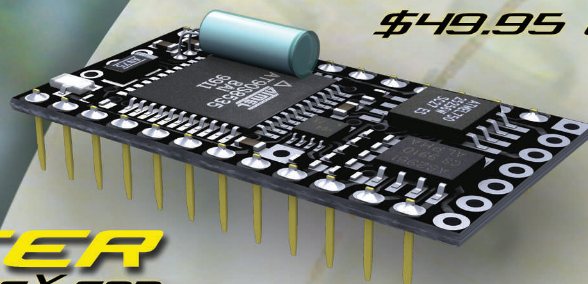

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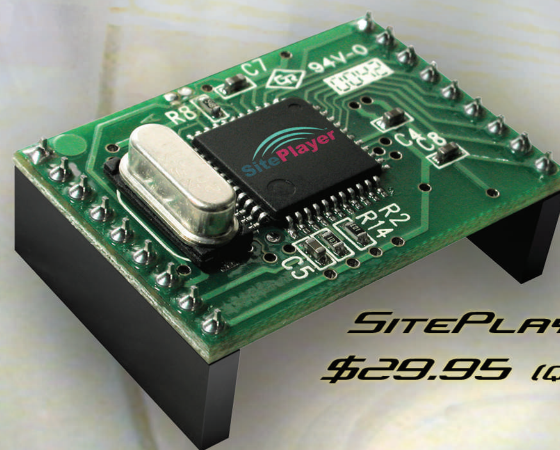

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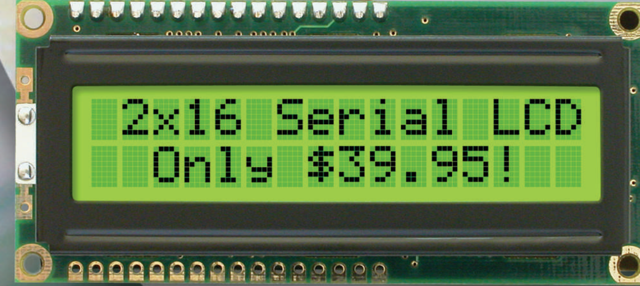

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Reader Feedback

Dear Nuts & Volts:

With interest, I read the question called The OBD Party in the November 2004 "Q & A." Several years ago, I purchased an interface module that is compatible with all post-1996 vehicles — with the exception of the CAN vehicles. I use my interface regularly with the supplied software from the interface manufacturer.

I went to their site today to see what was new and, not only are they still in existence, but you can still get the interface for $88.00! If you want the challenge of assembling it yourself, they also have kits that start at $38.00. The downloadable software is free of charge and compatible with all three protocols. Their website is: **www.obddiagnostics.com/**

Rick Gremillion
via Internet

Dear Nuts & Volts:

I'm a new subscriber and I really enjoy the magazine. I am writing to let you know how much I enjoyed the article "Tutorial on Diodes" in the September 2004 "Just for Starters" column. I would like to suggest a follow-up article on capacitors.

There is a bewildering array of capacitor types out there (electrolytic, paper, polystyrene, tantalum, ceramic, mica, etc.) and I have yet to find a good explanation on the differences between them and when to use one type over another. I'm sure other readers are in the same boat.

That's my two cents for now. Thanks for a great magazine.

Jim Lauk
Lutz, FL

Dear Nuts & Volts:

I've had no luck locating BUZ900D MOSFETS to build David Ponting's "Variable Resistive Load" from the December 2003 issue of *Nuts & Volts.* I have found the IRL540N (in a TO-220 pack) and wonder if it is possible to stack two or more in parallel, to increase the current rating?

Robert Snellman
Lincoln Park, MI

David Ponting responds: As I explained in the article, there are a large number of devices that will fit the bill for the MOSFET in my design and the main parameters which have to be watched are the on resistance (which should be as small as possible) and the wattage (which should be as large as possible). The BUZ900D is as ideal as I could find, but it is expensive and somewhat difficult to get your hands on. However, there is a US company that I am told will sell this MOSFET in small quantities: Martinez and Associates, 234 Boston Post Road, Wayland, MA 01778.

by J. Shuman

Dear Nuts & Volts:

I remember when I told my wife that I just paid $25.00 to *Nuts & Volts* for a lifetime subscription. We both wondered how long we would receive the magazine because it was a new company and you never know how long those will be around. It turns out we have received your magazine every month since 1980 and enjoy it very much. It was the best investment we ever made.

Ralph D. Reed
Apache Junction, AZ

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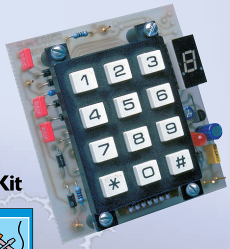

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Basics For Beginners

Just For Starters

Applying PWM — A Light Dimmer

Varying the power delivered to DC loads is a common problem in projects — such as robotics — where motors and lights require more control than simply on/off. Rapidly changing supply voltage to a DC motor or light is often impractical or disallowed by the electrical characteristics of the load.

A common solution is to apply pulse-width modulation — PWM. PWM applies a square wave signal to a load and varies the duty cycle of the square wave to change power consumption over time.

Figure 1 shows a varying duty cycle square wave. The load draws its full power during the on time and draws no power during the off time. As the duty cycle increases to 100%, the load draws more power. As the duty cycle decreases to 0%, the load draws less power. The circuitry necessary to modulate the square wave is relatively simple, thanks to integrated circuits and the availability of power transistors that can switch high currents.

When PWM is applied to drive a light in a properly designed system, the human eye perceives varying brightness rather than rapid blinking. The rapid on/off is visually averaged into a uniform brightness that is less than what would be seen if the light is on continuously.

PWM Solutions

There are many ways to implement a PWM solution. Purely digital solutions rely on a counter to time the on and off periods of the square wave. This can be done with a microprocessor or with hard-wired logic. Figure 2 illustrates the digital approach. The square wave period — 100 Hz — is defined by the system's reference frequency (10 kHz) and the counter's terminal count value (99). This configuration allows varying of the duty cycle in 1% increments, since each period is broken into 100 count values: 0 to 99. A duty cycle threshold register stores the count value at which the system's output changes from off to on (or vice versa). The threshold, in this case, is 40 and the system resets the PWM output to off each time the counter returns to 0. Therefore, the PWM output remains off for the first 40 counts and then switches on for the final 60 counts. This yields a 60% duty cycle. A comparator performs a "greater than or equal to" test between the counter and the threshold to determine the PWM output state.

The digital approach is practical if you already have a microprocessor designed into your system. An alternate approach is a dedicated analog PWM chip that modulates a square wave with an analog input signal. These chips can support a wide range of operating frequencies and very accurate modulation for applications requiring high precision.

Since PWM is often applied to high current loads, some PWM controller chips are able to directly switch certain loads to reduce overall system complexity. The analog input signal may be derived from a sensor and is used to vary the square wave's duty cycle, which is the modulation process. The input signal may be as simple as the voltage divider formed from a variable resistor (potentiometer) that is manually adjusted.

You can construct a simple PWM circuit with general-purpose linear integrated circuits (IC) instead of using a dedicated PWM controller chip. The two basic

Figure 1. PWM: Varying the square wave duty cycle.

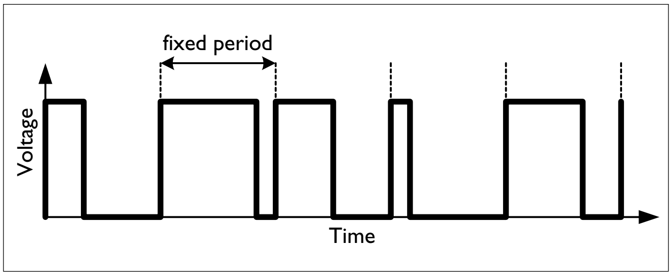
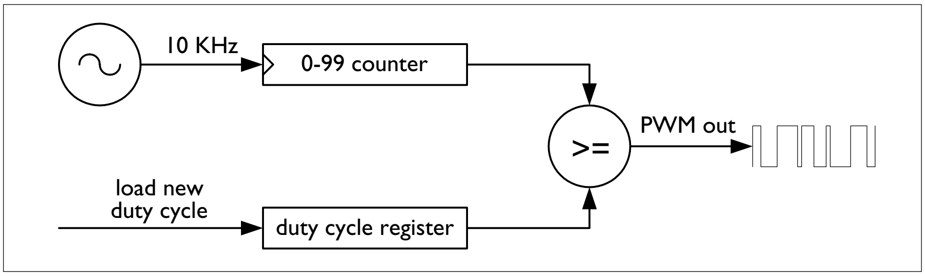


Figure 2. PWM implemented with a counter.



elements of a PWM circuit are illustrated in Figure 3: a time-base and a modulator. The time-base generates a constant frequency signal. The modulator varies the duty cycle of that signal based on an external input. We can employ an off-the-shelf IC for each element.

Do-It-Yourself PWM

The venerable LM555 timer IC is widely available and well suited to serving as the time-base generator for our PWM circuit. PWM frequencies vary, based on the application; 100 Hz is an acceptable frequency for varying the brightness of a light emitting diode (LED). You can select a lower frequency, though you should avoid too low a frequency, which might be perceived as blinking or might interact poorly with ambient lighting that pulsates at 60 Hz in the US.

Our time-base doesn't need to be highly accurate for this application, which allows for the LM555's usage of a resistor and capacitor for its timing. More stringent PWM applications may require crystal oscillators for tighter timing.

Figure 4 shows the LM555-based PWM circuit. Note that we do not use the LM555s in a typical square-wave output configuration. Instead, a current source — formed by PNP transistor Q1 — creates a linearly increasing voltage at the timing capacitor, C1. R1 and R2 form a constant emitter voltage at Q1, which creates a constant current across R3 that flows through the transistor and charges C1. Since the voltage across a capacitor is proportional to the charge on the capacitor divided by the capacitance, voltage increases as the current source charges the capacitor.

When the capacitor charges to approximately 3.3 V, it trips the LM555's internal discharge-reference, which abruptly discharges the capacitor and allows the charging process to begin again. R1 and R2 create a 3.4 V base potential at Q1 because the supply voltage is 5 V. This fixes the emitter potential at 4.1 V, causing 3.33 mA to flow through R3 and Q1. Since most of the current flows through Q1's collector, we can determine the charging time of the capacitor to sufficient accuracy by assuming that all emitter current flows into the capacitor. By choosing C1 to be 1 µF, we obtain a 10 ms capacitor charge time.

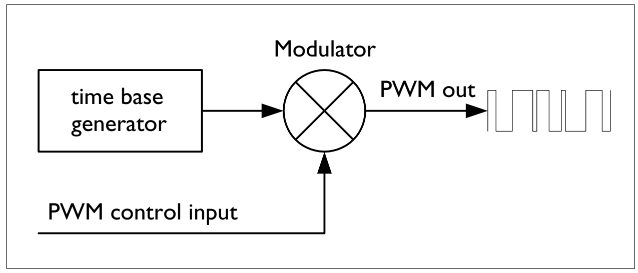
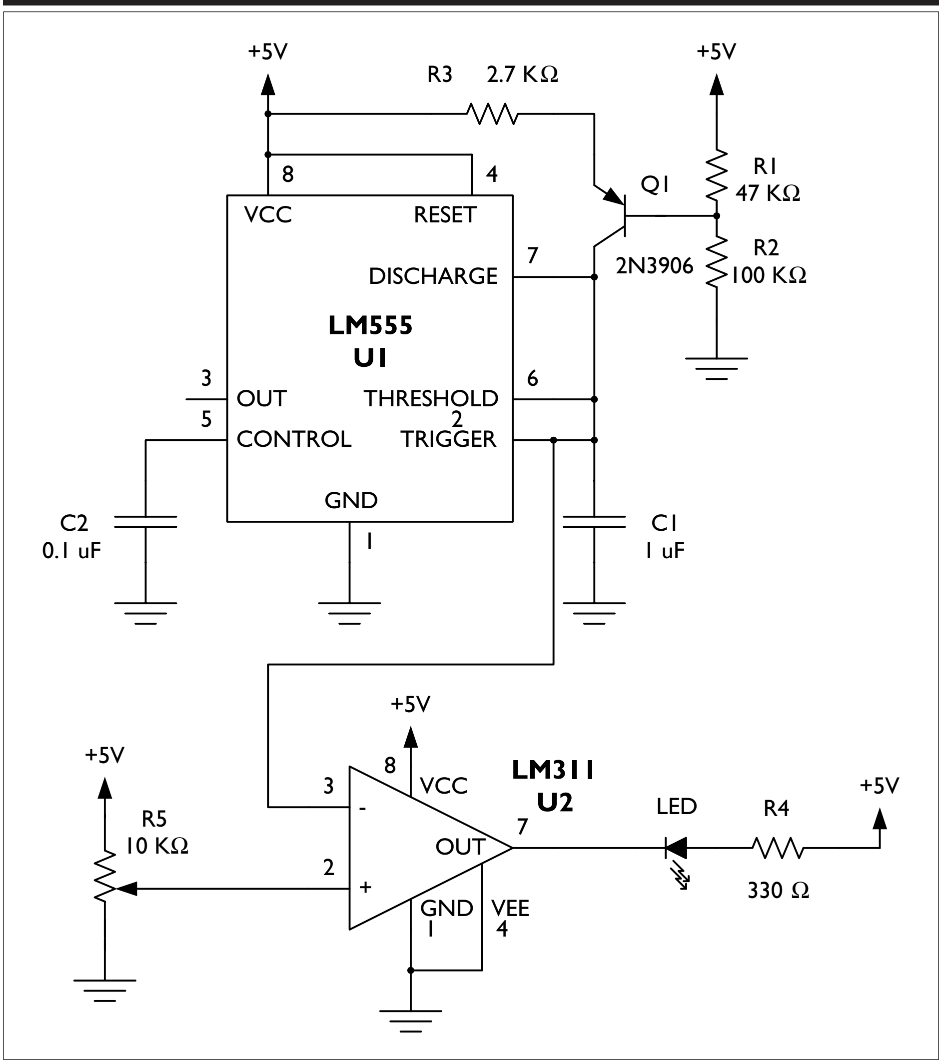


Figure 3. Basic elements of a PWM circuit.

Output Modulation

The LM555 creates the constant 100 Hz ramp pattern shown in Figure 5. A voltage comparator modulates the ramp pattern and converts the output to a square wave. As shown in Figure 4, the LM311 compares a threshold voltage — taken from the tap of a potentiometer — with the LM555 ramp pattern. The LM311 output is high when the LM555 ramp signal is less than the reference voltage formed by

Figure 4. LM555-based PWM circuit.



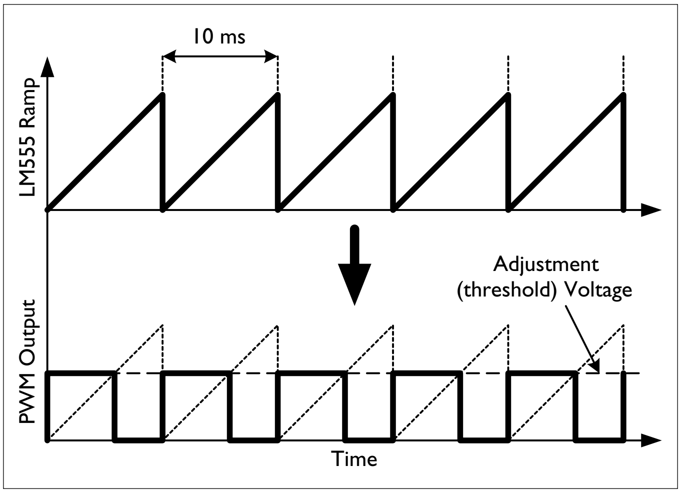


Figure 5. LM555 ramp pattern converted to PWM.

the potentiometer. In essence, you move up and down the LM555 ramp as the potentiometer sweeps from one extreme to the other. The comparator functions as a high gain amplifier that takes differences between its two input signals and distorts them in a binary on/off fashion.

Circuit Variations

The circuit presented here can be modified in a variety of ways. It is instructive to download the LM555 and LM311 data sheets from a manufacturer's website (try **www.fairchildsemi.com**) to learn more about their operation. The versatile LM555 can serve a wide range of timing applications. The LM311 is a common device that has moderately low input impedance. In this circuit, the LM555's 3.33 mA current source is much greater than the LM311's input bias requirement (several hundred nanoamps), so there is little error introduced by the LM311. Comparators with higher input impedances are available where required.

You can also add hysteresis to the comparator to handle slow or noisy input signals. Hysteresis stabilizes the comparator's response by enforcing wider thresholds between switching on and off, thereby absorbing low levels of noise. There are almost unlimited variations of these basic circuits that you can learn more about and apply to solve your own needs. **NV**

About the Author

Mark Balch is the author of *Complete Digital Design* (see **www.completedigitaldesign.com**) He can be reached at mark@completedigitaldesign.com

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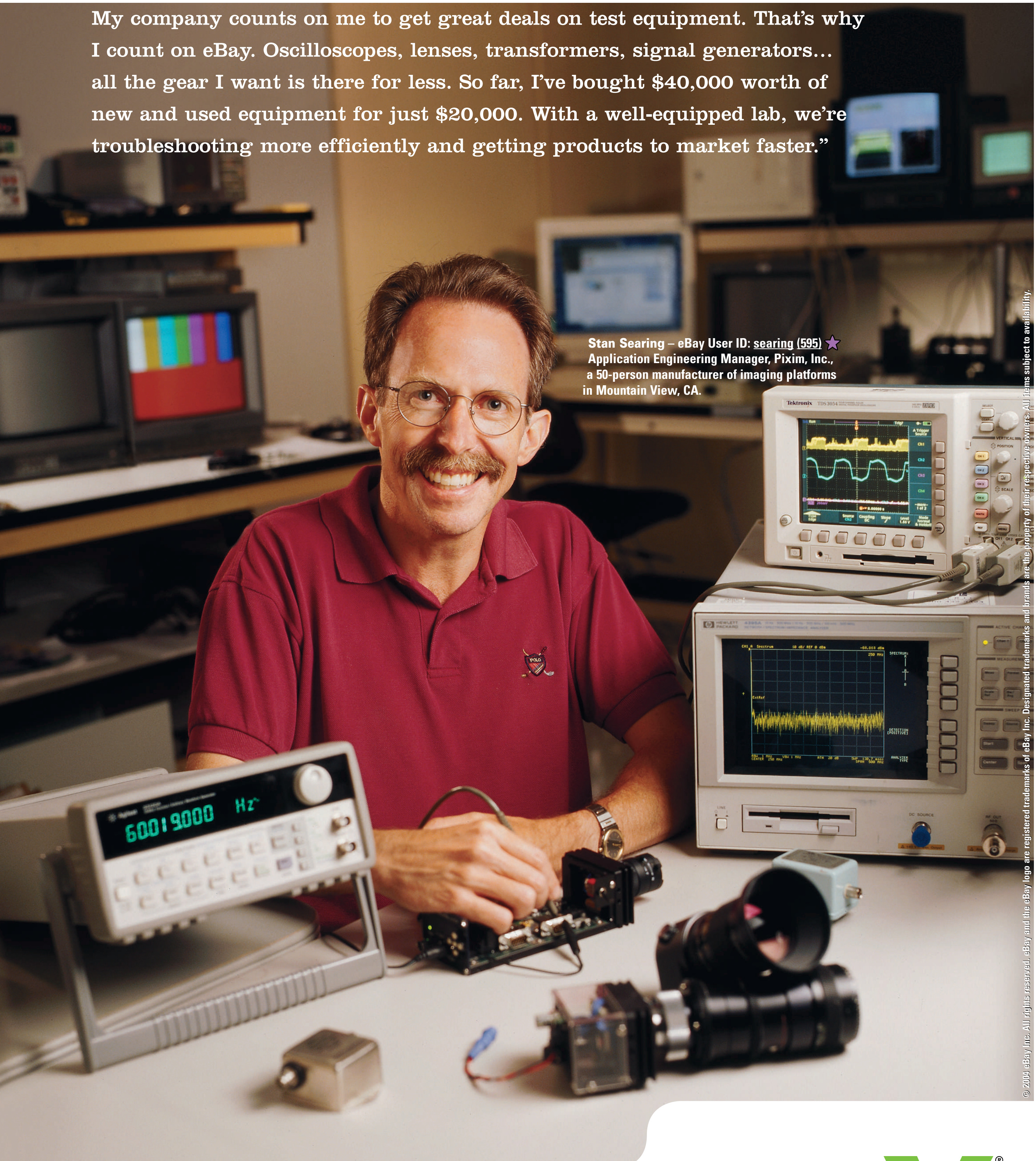

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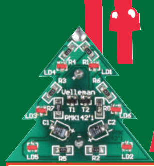
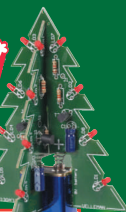

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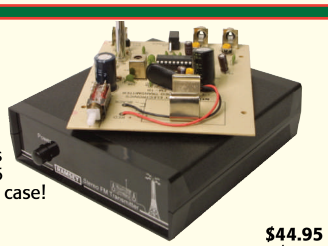

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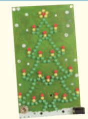
Animated Santa and reindeer display has 126 dazzling colored LEDs! Makes a great holiday sign! Animated motion makes it come alive. Runs on standard 9V battery or external power supply.

MK116	**LED Santa Kit**	**$19.95**

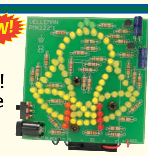
LED Christmas Tree NEW!



Electronic Christmas tree features 134 bright colored LEDs in the shape of a tree with 18 random flashing blinking "candles"! Runs on a 9V battery or PS.

MK117	**LED Xmas Tree Kit**	**$17.95**

LED Animated Bell NEW!



This holiday bell is animated to simulate swinging back and forth! 84 bright colored LEDs will dazzle you with holiday cheer! Includes an on/off switch. Runs on 9V.

MK122	**LED Bell Display Kit**	**$13.95**

3D LED Christmas Tree NEW!

Not your average LED display! 4 branch sections give this tree a 3D look! 16 red LEDs light it up with yellow LED's for you to customize your tree! 9V battery base.

MK130	**3D LED Tree Kit**	**$7.95**

SMT LED Christmas Tree NEW!

Build this subminiature Christmas tree and learn SMT at the same time. Small enough to wear as a badge or pendant! Extra SMT parts are included so you can't go wrong! Runs on Li-Ion cell.

MK142	**SMT LED Tree Kit**	**$8.95**

SMT LED Smiley Face NEW!

This is a great attention grabber and also teaches you the basics of SMT construction! Display your "smiley" as a pin or badge! Extra parts included!

MK141	**SMT LED Smily Kit**	**$8.95**

LED Traffic Signal NEW!

Impress your friends with this neat 4-way traffic signal! Operates just like a standard signal, and features adjustable delay. Red, yellow, and green LEDs are used just like the real thing! Runs on 9V battery.

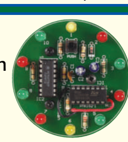
MK131	**LED Traffic Signal Kit**	**$7.95**

Stereo Super Ear NEW!

The stereo Super Ear features an ultra high gain audio amp with two sensitive microphones! Boosts audio 50 times! Includes volume control. Runs on 3 AAA batteries.

MK136	**Stereo Super Ear Kit**	**$9.95**

Wheel Of Fortune NEW!



Just like the casino game! Just push the button and the LEDs "rotate" and slowly come to a stop, displaying the "winner"! Push it again to start over. Runs on 9V battery.

MK152	**Wheel Of Fortune Kit**	**$7.95**

RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7	**RF Preamp Kit**	**$19.95**

Light Sensitive Switch NEW!

Senses light to turn your device on at night, off at dawn! Provides a NO/NC 5A relay contact. Adjustable delay. Runs on 12VDC.

MK125	**Light Sens. Switch Kit**	**$7.95**

What's New For 2005

The Newest Neatest Stuff!

Audio/RF Signal Generator NEW!

✔ DDS and SMT technology!
✔ 0 Hz to 5 MHz at 0.1Hz resolution!
✔ 0 to 10V peak to peak output level
✔ Sine, Square, or Triangle waveform

Following our world famous SG550, we are proud to introduce the SG560, the next generation signal generator!

To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) continuously in 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

SMT and DDS technology is used throughout the SG560 for ultimate performance and reliability. If you're looking for a lab quality sig gen at a super hobbyist price, the brand new SG560 fits the bill...and a whole lot more!

SG560WT Audio/RF Signal Generator, Factory Assembled $329.95

Digital FM Transmitters NEW!

✔ Rock stable PLL synthesized
✔ Front panel digital control and display of all parameters!
✔ Professional metal case
✔ Super audio quality!
✔ 25mW and 1W models!

For nearly a decade we've been the leader in hobbyist FM radio transmitters. Now for 2005 we introduce our brand new FM30 series of FM Stereo Transmitters! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!

The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then they redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in the non-volatile memory for future use.

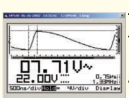
Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug in power supply. The stylish metal case measures 5.55"W x 6.45"D x 1.5"H and is a perfect match with your computer to broadcast your music files throughout your house.

FM30	**Digital FM Stereo Transmitter Kit, 0-25mW RF Output**	**$199.95**
FM35WT	**Digital FM Stereo Transmitter, Assembled, 1W, Export**	**$299.95**

Hand Held Digital Scope With DVM Readout NEW!

✔ Digital waveform and measurement display!
✔ 10MHz and 40MHz sample rates!
✔ Backlit LCD display
✔ RS232 output (40MHz model only)
✔ Charger, case, probes included

We've seen a lot of portable scopes and scope/meters, and we've also seen the price tags! They have always been way out of the reach and budget of the hobbyist. No more! Now for close to the price of a good DMM you can have a personal scope that also has DVM readout for dBm, dBV, DC, and True RMS! Frequency readout is also displayed on the screen through markers, plus the scopes have two memories for digital storage.



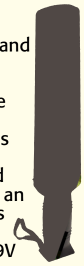
The 40MHz model also includes an RS232 output and serial interface to capture the screen display on your scope to your PC at the mere push of a button! These scopes run on 5 standard AA Alkaline batteries (not included) which provide up to 20 hours of use. You can also use rechargable AA NiMH batteries instead and they'll be charged with the included power supply! Both units come with a custom foam lined high impact carrying case, set of high quality scope probes, AC power adapter and a comprehensive user's manual. If you're working with electronic circuits, automotive applications, audio and stereo applications or other applications, the personal scope is for you...at a price that can't be beat!

HPS10SE	**Personal Handheld 10MHz Digital Scope**	**$229.95**
HPS40	**Personal Handheld 40MHz Digital Scope w/RS232**	**$299.95**

Get The Catalog!

Get the brand new 2005 Ramsey Hobby Catalog! ***64 value packed pages*** of the neatest goodies around! Order your copy on-line or give us a call!

Metal Detector Wand NEW!



✔ Professional Quality

Just like at the airports, this hand held metal detector wand detects the smallest metal objects hidden in both people and packages. Rocker switch turns the unit on and power is indicated with a green LED. When metal is detected, a red LED is illuminated along with an alert tone. Headphone jack is provided for private security checks. Runs on a standard 9V battery and includes a case & strap. Factory assembled & tested.

CS10MD Security Wand $54.95

Vehicle EL Wire Set NEW!

✔ Sound activated electroluminescence!

Now this is neat stuff! Nearly 10' of electroluminescent wire to install in your car. BUT...it gets better! A built-in sensor modulates the EL wire to the beat of music! Can be set for full mode, music mode, or off. Plugs into 12VDC car jack. Fully assembled.

NWRR30	**Red EL Kit**	**$27.95**
NWRG30	**Green EL Kit**	**$27.95**
NWRB30	**Blue EL Kit**	**$27.95**

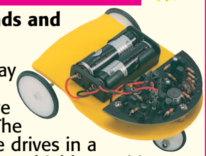
Electronic Watch Dog NEW!

✔ Sound activated barking dog on a PC board!

It's nice to have a barking dog to react to someone at our door. But not all of us can have a dog! No problem there, build your own! Two distinct barking sounds are sound activated with a built-in microphone that has adjustable sensitivity. I wish my dog had adjustable sensitivity! This dog eats 9-12VDC. Easy kit assembly.

K2655 Watch Dog Kit $32.95

Automatic Robot Car NEW!



✔ Senses sounds and turns!

This little car may not look like a robot, but it sure acts like one! The futuristic vehicle drives in a straight path, but a highly sensitive microphone detects sounds, and changes direction! Impress your friends, yell at it, clap your hands, and it listens, and then turns around! Runs on 2 standard AA batteries (not included) Gets great MPB.

KSR1 Robot Car Kit $19.95

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✔ Super comprehensive training manuals!

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Step up to our PL300, which gives you 300 separate electronic projects along with 165 page learning and theory manual. The PL300 walks you through the learning phase of digital electronics.

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PL130	**130 In One Learning Lab Kit**	**$42.95**
PL300	**300 In One Advanced Learning Lab Kit**	**$69.95**
PL500	**500 In One Super Learning Lab Kit**	**$169.95**

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Advanced Techniques for Design Engineers

The Design Cycle

A Specialized DSP-Equipped Microcontroller ...

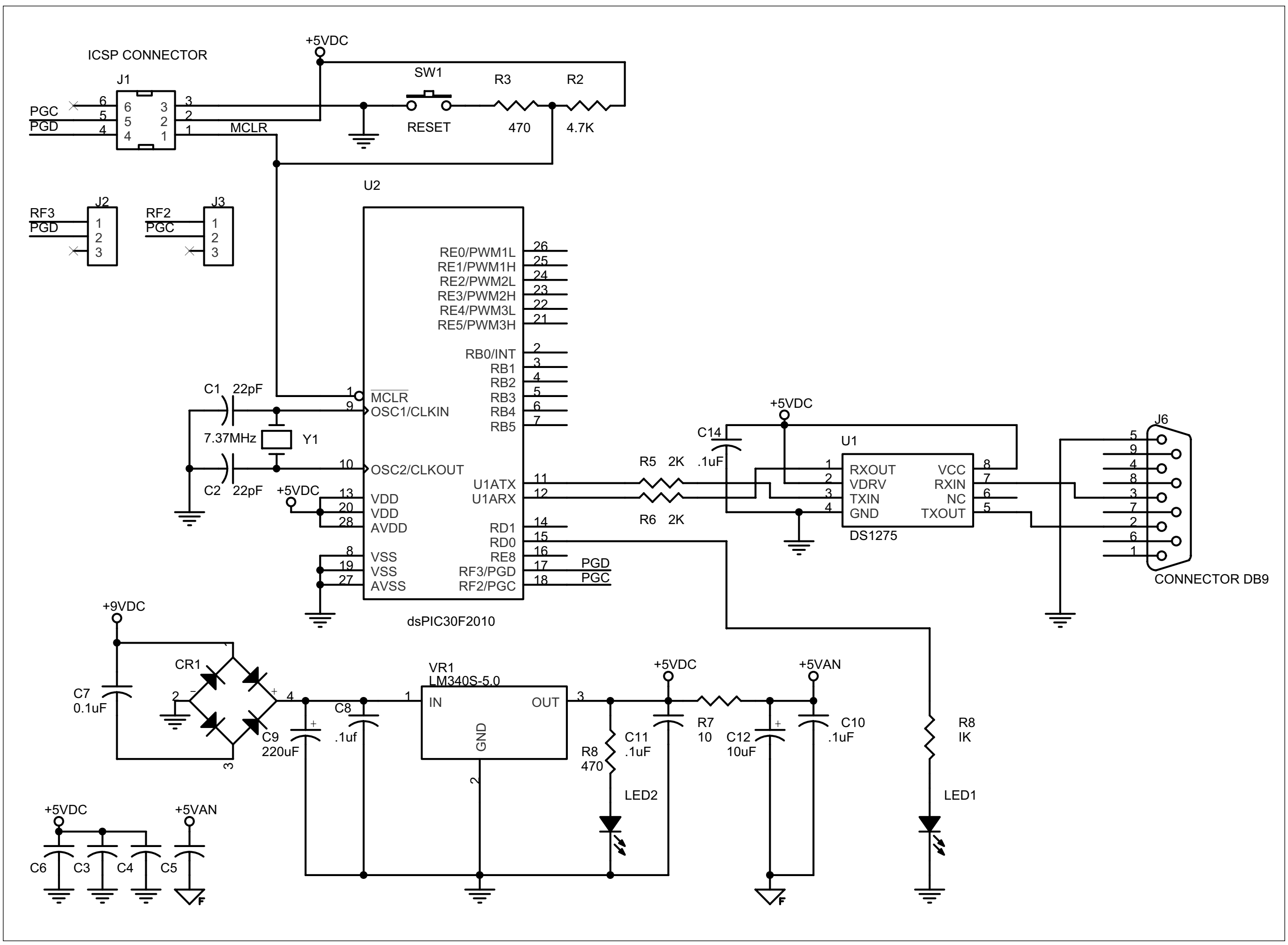
To perform DSP (Digital Signal Processing) tasks, you'll need a bit more than just math and some fancy programming. DSP hardware traditionally came (and still can come) as a dedicated DSP IC, which requires special compilers and debugging tools.

These days, DSP-equipped microcontrollers — like the Microchip dsPIC30F2010 — contain standard microcontroller features, like bidirectional I/O ports, timers, and USARTs.

In addition, a DSP engine and on-chip analog-to-digital modules that can sample incoming signals at up to 500,000 samples per second complement the dsPIC microcontroller hardware.

Sampling at high rates has its advantages, as you can get more of the incoming analog signal digitized and — as

Figure 1. The dsPICDEM 28-Pin Demo Board is very simple, as far as hardware goes. Most of the real action is taking place inside the DSP engine of the dsPIC30F2010.



a result — have a more accurate representation of the original signal in digital form. Remember, the goal of a DSP system is to get as much information as possible about the incoming signal as accurately as it can, since the quality of the resulting signal is dependent on the quality of the initial data acquisition.

To illustrate DSP concepts and firmware, I've chosen the Microchip dsPICDEM 28-Pin Demo Board. The dsPICDEM 28-Pin Demo Board is equipped with a dsPIC30F2010, which is the smallest IC in the dsPIC family, with 12K of on-chip Flash program memory and 512 bytes of on-chip data RAM.

However, the dsPIC30F2010 can run at 30 MHz, generating up to 30 MIPs.

In addition to the fast 10-bit analog-to-digital subsystem, the dsPIC30F2010 contains a DSP engine with two 40-bit accumulators, a 17-bit x 17-bit hardware multiplier, and a 40-stage Barrel Shifter.

As you'll find out as we go along, most DSP operations depend on the multiply-and-accumulate (MAC) process. The faster a piece of hardware can perform MAC operations, the better. The dsPIC30F2010 can perform a MAC operation in a single cycle.

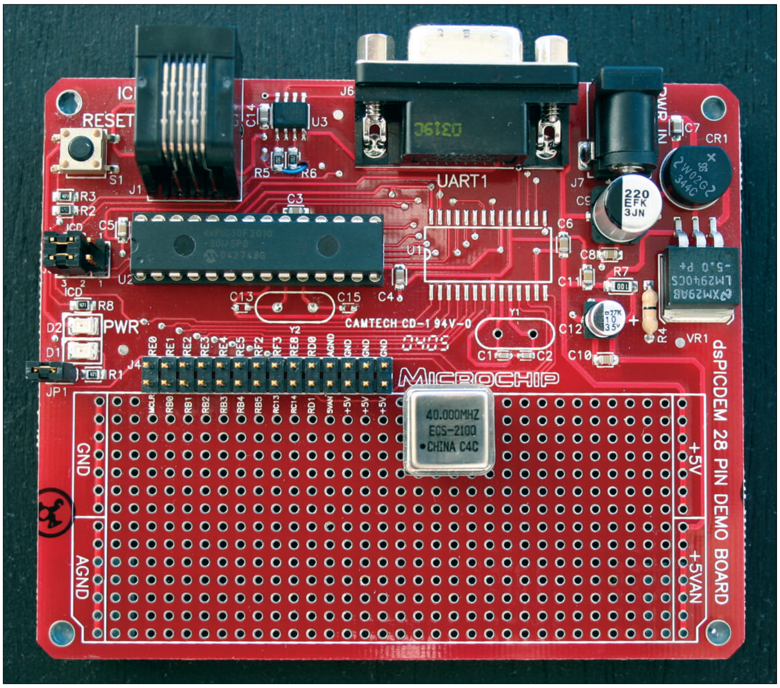


Figure 2. I drilled a small hole just next to R5 and R6 to run my TX an RX lines from the dsPIC30F2010 UART to the RS-232 converter IC.

The dsPICDEM 28-Pin Demo Board is clocked at 7.37 MHz. I've activated the dsPIC30F2010's oscillator PLL (Phase Locked Loop), which quadruples the internal dsPIC30F2010 oscillator output frequency. Using the oscillator PLL in multiply-by-four mode runs the dsPIC30F2010's CPU near its maximum internal clock speed of 30 MHz (29.4912 MHz, to be exact).

Pumping up the internal clock speed allows us to take advantage of the dsPIC30F2010's fast analog-to-digital hardware and DSP engine facilities. Although the CPU will be internally clocked in excess of 29 MHz, the UART uses the original 7.37 MHz clock for baud rate generation. The dsPIC30F2010 uses a 16-bit baud rate value for baud rate generation and at 7.37 MHz the maximum baud rate that can be obtained is 460 Kbps (7372800/16), which easily accommodates my desired baud rate of 57600 bps.

I'll be able to show you what's going on inside the dsPIC30F2010 using an inexpensive Microchip MPLAB ICD 2. The stock dsPICDEM 28-Pin Demo Board multiplexes the MPLAB ICD 2 programmer/debugger lines with the UART transmit and receive lines.

To avoid a conflict and to allow for super quick programming/debugging cycles, I slightly modified the dsPICDEM 28-Pin Demo Board's UART/RS-232 circuitry, which is centered around a DS275 RS-232 converter IC. I cut the traces that connected the RS-232 ICs transmit and receive pins to the MPLAB ICD 2 interface pins and relocated the transmit and receive pins of the RS-232

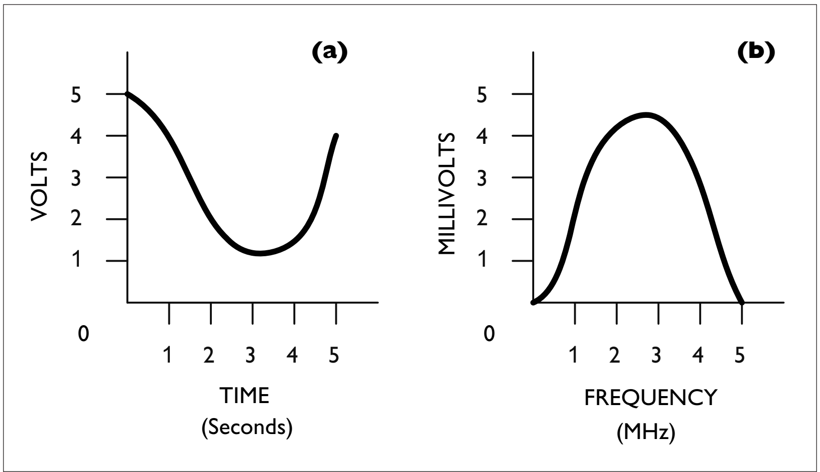


***Figure 3**.* (a) This would be a very slow moving signal in the real world. Voltage is a function of time in this example. (b) The X axis denotes the domain of a signal. In this figure, the voltage is a function of frequency.

converter IC to the dsPIC30F2010's alternate UART TX/RX pin set.

All of my mods are reflected in the schematic (Figure 1). The hardware used on the dsPICDEM 28-Pin Demo Board is very simple and easy to obtain. If you don't choose to purchase this particular demo board, you can easily build up the dsPIC30F2010 circuitry yourself. My hot rod dsPICDEM 28-Pin Demo Board is shown in Figure 2.

The C compiler of choice for our DSP discussion is HI-TECH's dsPICC Compiler.

In addition to the standard PIC mnemonics, the dsPICC compiler has all of the dsPIC DSP engine definitions built in to allow us to manipulate the DSP peripherals found on-chip within the dsPIC30F2010.

Class Dismissed ...

Now you have some basic DSP signal theory under your belt. Next time, we'll fire up the dsPIC30F2010 and run some analog-to-digital and digital-to-analog routines to illustrate some more of the aspects that make up the DSP discipline.

I'm not about to leave you empty-handed. Here's some necessary code to initialize the dsPIC30F2010's UART and enable the dsPICDEM 28-Pin Demo Board's serial port. We're going to need this next time, if we want to debug and observe the results of our analog-to-digital and digital-to-analog operations.

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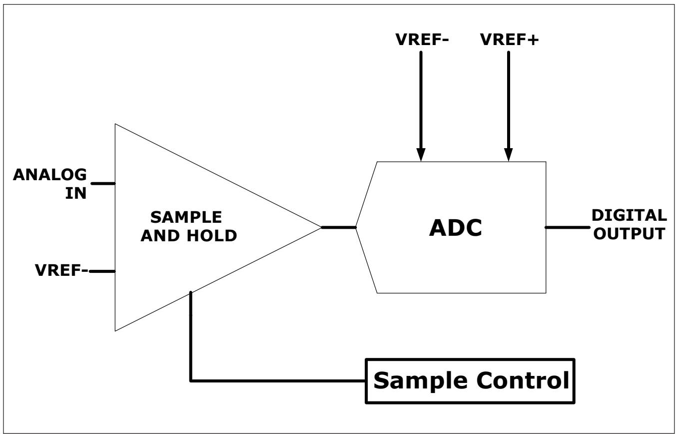

Figure 4. This is greatly simplified; however, it does convey the thought. The discreet Y axis value (independent variable) is supplied from the output of the sample and hold circuitry while the discrete X axis value (dependent variable) is being generated by the sample control mechanism. The only continuous signal in this figure is at analog in.

```
#include <dspic.h>

__CONFIG(FOSC,POSC & XTPLL4 & CLKSWDIS & FSCMDIS);
__CONFIG(FWDT,WDTDIS);
__CONFIG(FBORPOR,PWRT16 & MCLREN & BORDIS);
__CONFIG(FGS,GCPU & GWRU);
__CONFIG(FCOMM,PGEMU);

#define BAUD1        57600
#define OSC1         7372800
#define DIVIDER1     (((OSC1/BAUD1) /16) - 1)
void main(void) {
  U1BRG = DIVIDER1; //load the baud rate generator
  U1_UARTEN = 1;    //enable the UART
  U1_ALTIO = 1;     //select alternate TX/RX pins
  U1_UTXEN = 1;     //enable transmitter

  while(1){      //echo character received forever
    while(!U1_URXDA);    //wait for a received character
    while(!U1_TRMT);     //is transmit buffer empty?
    //if transmit buffer is empty.. send character
    U1TXREG = U1RXREG;
}
}
```

The UART code here simply echoes any character it receives. I'll embellish on this code the next time around. In the meantime, get yourself some dsPIC hardware and be ready to do some serious DSP stuff with me when I return in the February issue of *Nuts & Volts*. **NV**

RESOURCES

HI-TECH Software
HI-TECH dsPICC C Compiler
www.htsoft.com

Microchip
dsPICDEM 28-Pin Demo Board
MPLAB ICD 2
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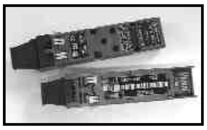

New, by Infineon. Has laser transmitter and receiver in one package! 1.25 Gb/s data rate up to 700 M on low cost multimode fiber! Super small size, complete specs on the web. Make your own fiber optic link!
0125461R (Set of two) $19.95

Hitachi LCD display

16 character by 2 lines 5x8 dot matrix character 64.5 x 13.8 mm viewing area STN neutral mode reflective LCD recently discontinued by Hitachi but a very common and most used part. Directly crosses over to the Optrex DMC16249, brand new stock!
0123260R $4.95

Laser Scanner Bar Code Module

Wow! What a a cool item! Brand new laser scanner module (size 1x1x1.5"!) includes red laser, beam splitting mirror, opamps, photo sensor, transistors, processor, ICs, etc. From handheld laser barcode reader. We sold out of the last style we had! No specs, but buyers figured out the hook up for the last group, we'll post on the web any new info on this one, should be easy, has just 12 pins on the connector.
0131346R $14.95

C size Nicad Battery

This is the real deal, a true 2 A Hr Nicad, Button top works in any device too! Brand new by Sanyo.
0130380R $2.00

Powerful DC Motor

Made by Johnson Electric
12 VDC @0.85 A no load, 17,000 rpm, 3 vdc @ .51 amps 4,200 rpm, 6 vdc @ .6 amps 8,500 rpm. Similar to Johnson Electric HC313MG series but higher power. Actually runs as low as 1 volt oper ation! (1200 rpm .46 amps). Size: 2" l x 1.5" dia 7/8" long eccentric brass shaft end easily broken off to form a .5" long x .312 dia round shaft end.
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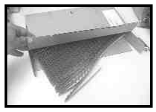
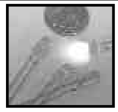
LED BLOWOUT !!!


Here's a deal that just will not last long Wind sor's LED Blowout! Super high quality, factory prime bright LEDs. Ideal for all those projects that you've wnated to build, but just didn't have the quantity of LEDs needed. You will not find pricing like this ever again we bought out two factory inventories! Here's the scoop: Big bag o leds have 500 pcs and are all RED jumbo 5 mm size with crystal clear bulbs. You pick the lumi nous intensity, bear in mind that the 2500 mcd high bright units are flashlight intense! Big buy ers will love the 2,000 LED boxes! These LEDs are the smaller T 1 size with full leads, available in Red or Green. Imagine 2,000 Leds for less than a penny each!
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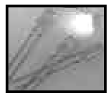
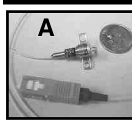
0131292R Standard Bright 500 pc bag $15.00
0130956R Box o leds Red 2,000pcs $19.95
0130955R Box o leds Green 2,000pcs $19.95

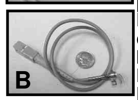
Windsor's Blue LED Special



Holy Smokes! Can you believe the price on this BLUE LEDs? First quality from our factory buyout. Big and bright! These normally sell for $1.50 each and that's in big quanti ties! We're crazy to sell 'em so cheap!!
0131297R 50pcs $19.95
0131297 500pcs $99.95

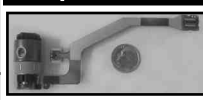
Laser Fiber Optic Transmitter





Brand new HP Agilent model LST2829 Laser transmitter mod ule. Capable of 622 MB/s data rates, 1 mW output power, 1300 nm wavelength, includes on chip power monitor diode. These are high end quality lasers and not often found on the surplus mar ket! Two style available, A: 32" long thin pigtail fiber and B: 16" long encased fiber. Each has the same electrical specs. Price: $9.95 each
Item A: 0128526R Item B: 0128536R

Cellphone CMOS Camera Module



Wow! Here's the guts of the camera in all the new cellphones. Brand new assemblies made by Pic tos, model 0187837M11. Camera head has neat rotating head and snazzy look. Flexible circuit board has tiny connector on end for hook up. Opening the cam era head reveals a super tiny sin gle chip camera IC that is only 3/8" square including built in lens! Sorry we have no specs on this unit, but should be easy to research on the net or with a scope.

0128842R $8.95

Tool Set


Well made quality 3 piece plier set. Includes deluxe padded zipper case. Pliers are big 8" in size, you get: needlenose, diagonal and lineman style with handy crimper and stripper dies on each tool! Get a few for the car, gifts and toolbox, they are that nice!
0128871R $12.95

Check our web site for more great deals!

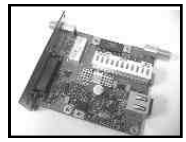
Truck Stereo

New in dash cassette stereo AM/FM radio, LCD display, drives 4 speakers (80 watts!) Even has Weather band! Quality fully enclosed case, easy hookup, great for in wall home installations! Runs on 12 VDC.
0128872R...$29.95

Ion Generator

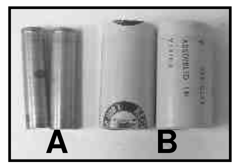
Build your own Ion Breeze air purifier! New module, 120 VAC in, 7.5KV out! Surplus from air cleaner maker who sold them for $200!
0128873R $7.95

Cellular Bi Directional Amp

Super rugged unit features powerful 3 watt RF amplifier for transmit and sensitive receive amplifier. Utilizes diplexer ceramic fil ters. Additional circuitry for protection, regu lation, etc. Sorry, we have no specs on this, but its a treasure trove for the experimenter and RF guru. Brand new. Size: 4.5 x 5 x 1.5" in rugged extruded aluminum heat sink style case. Uses mini UHF connectors.
0127460R $14.95

Rechargeable Battery Blowout!

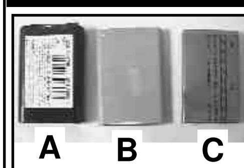


Popular Nicad batteries, 1.25V all brand new, recent stock. A &B are NiCad and C is NimH.
A: AAA 400mah 0125339R 2 for $1.00
B: Sub C 2500 mah 0125443R 2 for $1.75
C: 3.6 Volts 750mah 0125348R 2 for $3.00

Nice, new 5 AA cell nicad pack. 6 Volt 700mah with 6" wire leads. Great for projects or cordless phone replacements.
0125345R.....................$2.50

Big box of 50 brand new AA button top NiCads. Fit anywhere an AA battery does. 1.25V 800mah. Best price in the USA!
0128870R.............$19.95

Lithium Ion Rechargeables !!



Rechargeable Lithium batteries pack the highest density of power for size and weight! Ideal rec tangular size is easy to fit in your project. All 3.6 Volt and approx rated Amp Hour capacity.
A: 1Ah 1.95x1.34x.4" 0125337R.....$1.50
B: .8Ah 1.95x.1.34x.25" 0125349R.....$1.25
C: .8Ah 1.95x1.24x.23" 0125350R.....$1.25

www.shopatwindsor.com

Circle #54 on the Reader Service Card.

Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at:
TJBYERS@aol.com

What's Up:

Keeping with this month's theme, every answer is project oriented. How about a pair of LED flashlights? Max Headroom lives again in a mike preamp. Digital pots, R/C servo modifications and a mailbox alarm are also in the mix. Plus more.

Panel Meter Pepper-Upper

Q. I have a large collection of good panel meters, but find that many of them are not sensitive enough. Could you print a simple, one-transistor circuit to "pep" them up using a 2N2222 or similar transistor?

Fran Hillibush
via Internet

A. Would you go for an op-amp? The circuit in Figure 1 is what is sometimes called a current-to-voltage converter. We recognize it as an inverting op-amp.

Actually, they are one and the same. In this configuration, the output of the op-amp is forced to feed back a current equal to the input current through Rf. This way, the op-amp is in "balance." If the Rf is greater than zero, then the output voltage must increase to compensate for the Rf current loss.

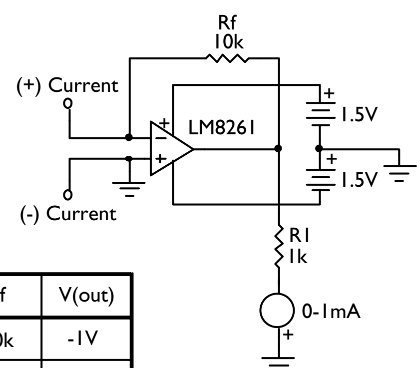
For example, if the input current is 100 µA and Rf is 10K, the output voltage must be 1 volt to force enough current through Rf to equal the input current. If the input current is 10 µA, then Rf becomes 100K with a 1 volt output. The formula is -V(out) = I(in) x Rf.

Now, let's go to the other end of the equation, where the output voltage translates into a current to drive your panel meter.

For this example, I've selected a 0-1 mA panel meter — a very common analog meter you can find at RadioShack under the guise of a 15 volt panel meter (22-410). With the values shown in Figure 1, a 100 µA input will generate a 1 volt output. Using Ohm's Law (R1 = E/I = 1/.001 = 1K, where .001 is the full-scale of the meter), we need a 1K resistor. If you're using a 10 mA meter, R1 becomes 100 Ω. By changing the value of R1, you can make any meter into a 100 µA meter — up to a point. The current output limit of the LM8261 is about 50 mA; that is, it won't drive a 100 mA meter.

I chose this op-amp because it's small, has rail-to-rail output, and can work on two 1.5 alkaline batteries, but feel free to replace it with just about any general-purpose op-amp, as long as you meet its minimum operating voltage requirements (e.g., ±5 volts for the LF353).

Figure 1



I(in)	Rf	V(out)
100uA	10k	-1V
50uA	50k	-1V
10uA	100k	-1V
5uA	500k	-1V
1uA	1M	-1V

Ammeter Amplifier

Digital Potentiometer Manual Control

Q. I plan to make a stereo amplifier using an LM4753 that uses a DC volume control. Instead of using a volume control, I would like to

know if I could use a digital potentiometer. Catalyst makes them and Mouser sells them for less than $2.00. Can you supply a diagram of how to use a digital pot for audio purposes?

Robert Jemmings
Rehoboth Beach, DE

A. First, some reader background: A digital potentiometer is basically a DAC device that mimics the operation of a mechanical pot. It does this by using logic switches to tap into an internal ladder resistor. The taps are switched in and out sequentially so that the resistance follows a linear path. The number of taps determines the resistance difference between the steps and the resolution (coarseness) of the pot. The higher the number of taps, the smoother the operation.

For example, a 10K pot with 32 steps has a resistance change of 312.5 Ω per step, whereas a 10K pot with 256 steps has a resistance change of just 39 Ω per step.

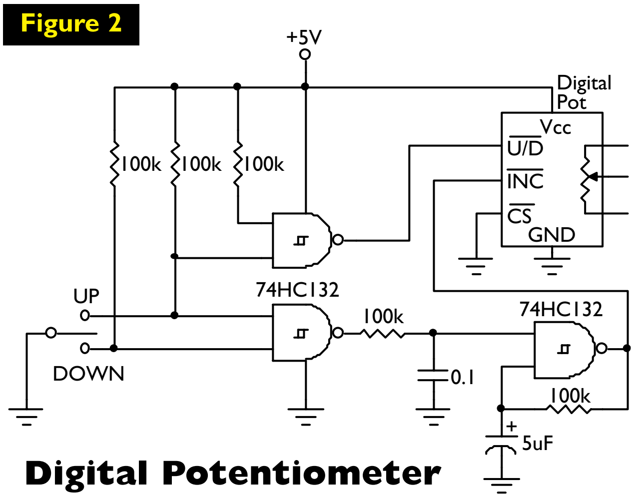
Inside the digital pot is an up/down controller that steers the direction of the taps. The user interfaces this controller through three methods.

One method uses computer protocols — like I^{2}C or SPI — to name but a few. Other digital pots — like the AD5228 from Analog Devices — have internal circuitry so that you have only two pins to contend with: increasing resistance or decreasing resistance.

The most popular interface for hobbyist and many audio applications is the incremental up/down method. This uses three inputs. The up/down pin directs the direction of the count and the increment pin provides the clock that steps the controller. The third pin is a chip enable that's grounded for normal operation.

A simple manual interface using this method is shown in Figure 2. A momentary SPDT switch with a center off position (RadioShack 275-705) operates the digital pot. When the switch is turned on in either position, it grounds one of the inputs of the lower NAND gate, which forces its "output high. This starts the oscillator (right NAND gate) that clocks the INC input. If the switch is in the UP position, it also grounds the input of the direction gate (upper left), which forces its output high and sets the U/D pin to count up.

Figure 2



Digital Potentiometer Manual Control

The frequency of the square wave oscillator is about 3 Hz; you may want to raise or lower this frequency by changing the 5 mF capacitor to match the step number of your particular pot. A 32-step pot needs a larger cap (lower frequency) than a 1,024-step pot does.

Max Headroom

Q. I have a Sony Handycam DCR-HC40. When I tape my son's rock band, the built-in microphone — as well as the external microphone — are overloaded from the intensity of the loud music and, hence, there's distortion on playback. I'd like to control the gain to the camera microphone input either automatically or manually. Do you have information or a website on building an adjustable gain microphone amp? The camera has an external microphone input that provides some DC power.

Larry Smith
Richmond, IL

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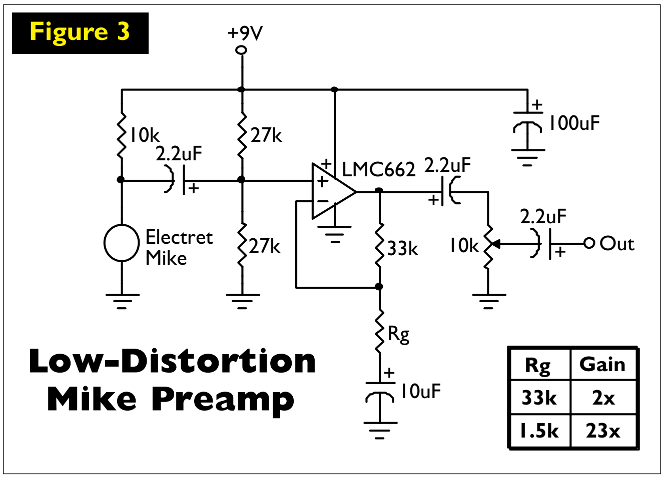
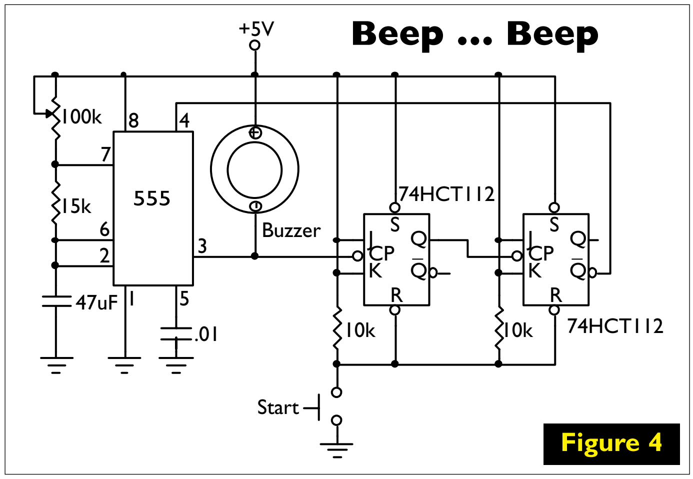
SO. FLORIDA SECTION CONVENTION



Rg	Gain
33k	2x
1.5k	23x

Figure 3

Low-Distortion Mike Preamp



Beep ... Beep

Figure 4

A. Your problem is not enough headroom. At loud volumes, the music peaks are being clipped, which is causing your distortion. What you need is an op-amp circuit with programmable gain that allows for large voltage swings without clipping, like the circuit in Figure 3.

The first condition is to boost the power supply voltage and current to a level where it can handle the signal by switching from the Handycam's internal battery to a 9 volt radio battery. This will provide an undistorted 1.8 volts of swing. The gain of the amplifier is controlled by Rg using the formula Gain = ((33K/Rg) + 1). With the values shown, the gains are 2, which is suitable for live music — like your son's rock band — and 23 for everyday recordings. The 10K pot adjusts the level for input to your recorder.

Two Is Enough

Q. I need a circuit operating on any voltage between 1.5 and 12 volts (1.5 volts preferred) that will output an audible beep about 3 seconds after throwing a switch (I can use either a regular or momentary switch), then beep again after a random delay of about 1 to 5 seconds after the first beep.

Randy Schroeter
via Internet

A. Random? Not easy — but I can give you a simple circuit (Figure 4) that will give you two beeps per press, with an interval that you can vary using a single control. The heart of the circuit is the 74HCT112 flip-flop. (Are you surprised it isn't the 555?) This is a J-K flip-flop that changes state with every clock pulse and can be found in ripple counters. The start button resets the flip-flops so that the reset input (pin 4) goes high and starts the time.

After a time determined by the 100K pot, the piezo beeper will sound for about half a second. The beep will repeat itself one more time and stop. That's because the flip-flop output on pin 4 has now flopped (gone low) and shut down the 555. If you can find a J-K flip-flop that works down to 1.5 volts (they exist, but are not readily available), you can replace the 555 with the Z1555 and reduce the 5 volts to 1.5 volts.

For those readers who want the same beeper feature without the push-button, replace the switch with the output of a logic gate driven by your circuit. All you need is a momentary zero-logic (GND) output pulse to reset the flip-flops.

EL Panels?

Q. Whatever happened to electroluminescent panels? They change color and brightness with changing voltage and frequency.

Craig Kendrick Sellen
via Internet

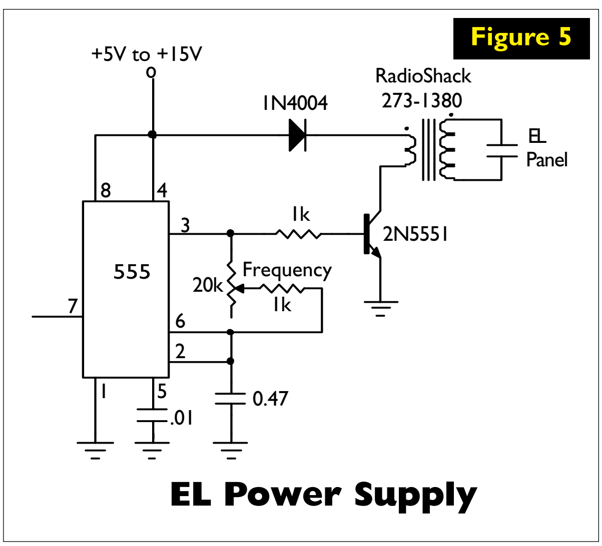


Figure 5

EL Power Supply

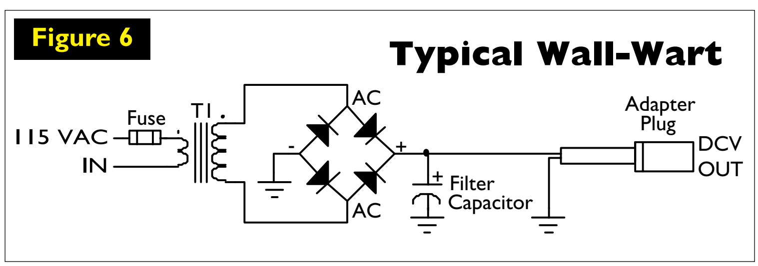


Figure 6

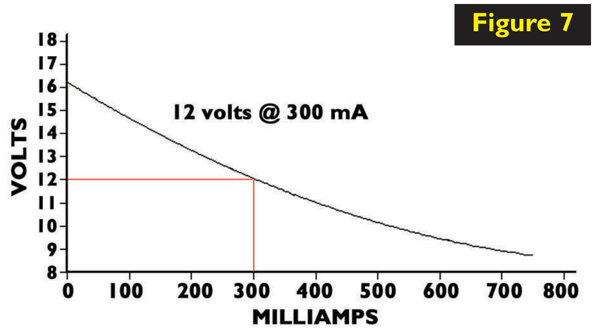
Typical Wall-Wart

A. EL panels are still alive and well. They are often used in backlighting for LCD displays and in cell phones. You can also find them as "rope" lamps in window displays and in custom automotive applications. Yes, they do change brightness and color to some extent (depending on the particular color and manufacturer) with voltage and frequency.

An interesting feature of EL panels is that you can cut them into any shape you desire with a pair of scissors and not break the circuit. You can find EL strips and kits at All Electronics (888-826-5432; **www.allelectronics.com**). EL ropes can be found at most auto parts stores.

Although most EL products come with their own power supplies, you'll want to change the voltage and frequency to satisfy your curiosity. The power supply in Figure 5 fills that need. The 20K pot varies the frequency from 68 Hz to 1.4 kHz; the output voltage is adjusted by a 5 to 15 volt power source (start with a 9 volt battery). Like fluorescent lamps, the brightness of the EL fades with age — a process which is accelerated with increased voltage and frequency.

Figure 7



Wall-Wart Voltage Regulation

Wall Wart Blue Light Special

Q. How do you supply DC volts using the 120 VAC line power without the use of a transformer — for example, the +12 V needed for the "Attic Fan Controller" on page 32 of the August 2004 issue?

Gordon Winram
via Internet

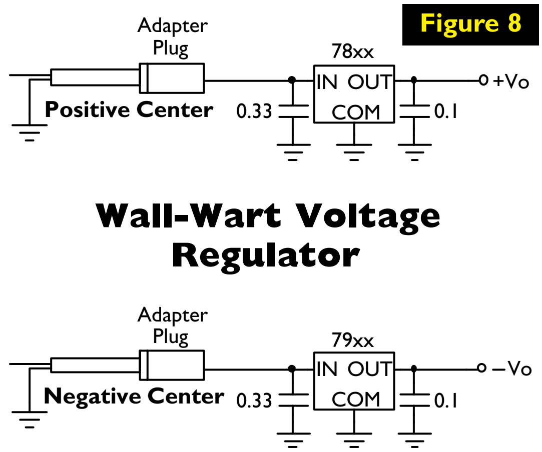
A. Unless otherwise stated, all of my circuits in "Q & A" can be powered by a wall wart. What's a wall wart, you ask? It's that "brick" that comes with your boombox or cordless telephone — the black (or white) box that you plug into the wall. Inside that mystery box is a transformer, a rectifier, and — usually — a filtering capacitor (Figure 6).

Wall warts are rated according to voltage and current, as in 12 VDC at 300 mA. The match is simple: Choose a wall wart that meets the circuit's voltage and current requirements.

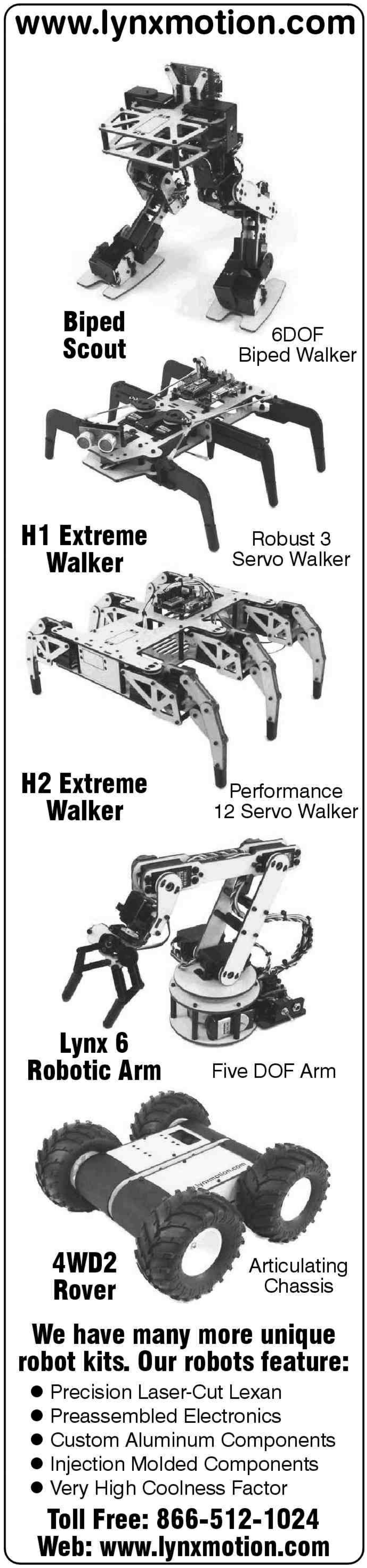
However, not all wall warts are created equal and you have to pay attention to more than just the ratings.

First and foremost is the connector. Even though they are all the same barrel shape, the outer and inner measurements differ considerably. The most popular are 3.5 mm OD (outer diameter) with a 1.3 mm ID (inner diameter) and 5.5 mm OD with 1.2 mm and 2.5 mm ID.

Figure 8



Wall-Wart Voltage Regulator



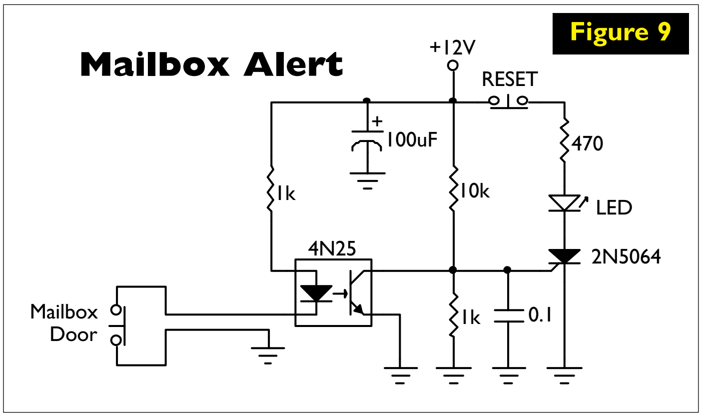


Figure 9

Sometimes, the inner pin is positive and sometimes it's negative. Make sure you know the difference before you plug it into your circuit.

There is also an issue of voltage regulation — or lack thereof. Let's go back to the 12 volt, 300 mA wall wart I mentioned. With a light load, a 12 volt wall wart can pump out in excess of 16 volts. Load it and the output voltage drops (Figure 7). At 300 mA, you're at 12 volts. Nudge it a bit more — say to 400 mA — and you're looking at 11 volts.

Normally, this isn't an issue because I always include a 78xx regulator in circuits that are voltage-sensitive.

Then again, it's easy enough to make your wall wart into a regulated voltage source. Simply add a three-terminal voltage regulator and two capacitors. Figure 8 shows a voltage regulator circuit for positive and negative input voltages.

Remember, the wall wart voltage has to be at least 2 volts higher than the regulator voltage and the current is limited to 1 amp.

Mail Delivery Alarm

Q. I built a remote mailbox alert circuit described in the July 2000 *Poptronics*. When the box opened, a switch engaged and fired an SCR — so far, so good. But it didn't work for long, so I replaced the transistor and SCR. Again, it worked, but not for long. I assume something is failing. What is it?

T. Hunter
via Internet

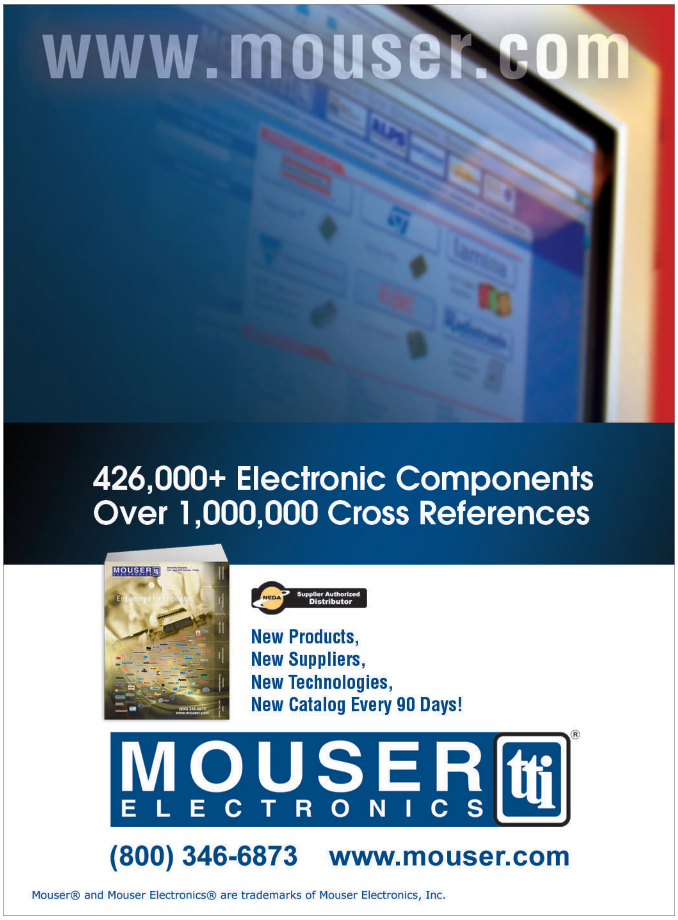
A. I looked over the circuit and it seems solid enough — for a PCB design — but not for a long wire run with a normally-open switch at the terminal end, which basically makes the wire run into a big antenna. That is, any EMF that comes down the line is going to be fed to your indoor sensor electronics. Those spikes can be pretty severe. You know the rest.

Instead of a high impedance open loop, what you need is a low impedance loop with current flowing through a closed switch that is interrupted when the mail door opens. In fact, it was one reason that the 4-20 mA instrumentation standard was established. Current flow equates to lower impedance, which equates to smaller spikes.

Here's what I'd do. (I've saved as much of your original parts investment as I could, most of which I would have used anyway.) Use a normally-closed mailbox switch and have it drive an optocoupler, like a 4N25 (Figure 9). Have the 4N25 transistor short out the signal to the SCR so that the SCR only triggers when power is lost in the loop. This configuration also has the benefit of detecting breaks in the line (another reason for the 4-20 mA standard). Yes, it draws constant power, but — for this application — it's the right solution.

White LED Flashlight

Q. I bought a pile of high output white LEDs to make emergency lighting for my ARES (Amateur Radio Emergency System) radio station. The LEDs say they have between 3.5 and 4.5 forward voltage drop. I thought of using them with C or D flashlight cells and installing them in the shade of an outdated gooseneck "intensity lamp."



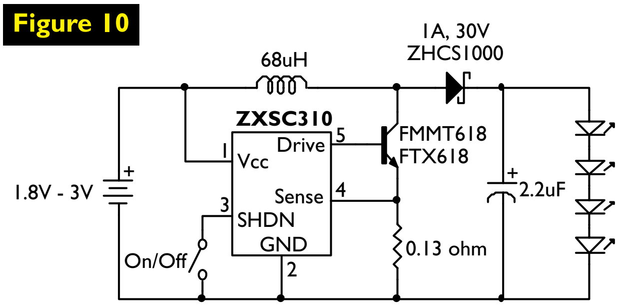
Circle #29 on the Reader Service Card.

My problem comes when I try to create a constant current source. My past experiments with LEDs have been with 5 volt regulators, but I don't have enough "head room" here for that solution. If I configure the LEDs in series, the voltage drop exceeds that of a reasonable battery pack. Can you help me out with a circuit that works with either flashlight batteries or a gel cell?

Richard Herndon
Bastrop, TX

A. The circuit in Figure 10 will light four white LEDs from two alkaline D cells. The ZXSC310 is a pulse-frequency modulation (PFM) controller specifically designed for white LED operation in applications like LCD backlighting in cell phones, PDAs, and digital cameras.

Figure 10



LED Flashlight

For your application, I've adopted a circuit from a Zetex Design, Note 64.

All parts are available from Digi-Key (800-344-4539; **www.digikey.com**). Feel free to replace the surface mount FMMT618 with the E-Line (TO-92) ZTX618 and the ZHCS1000 with any generic 1 A Shottky diode. The only critical component is the inductor, which has to be a high current type with a 0.4 A minimum rating.

It's also recommended that the sense resistor be a 1206 size surface mount device, but it's not a requirement. A PCB layout pattern for a SMD version of this design can be found on page 12 of the ZXSC310 datasheet (**www.zetex.com/3.0/pdf/ZXSC310.pdf**).

MAILBAG

Dear TJ,

Concerning lightning, as mentioned in the September 2004 issue, I have some comments.

Ninety to 95 percent of cloud-to-ground lightning strikes are negative strikes wherein the cloud is negative and the ground is positively charged. The remaining strikes are positive. While negative strikes are usually accompanied by rain, the positive ones are not and are a major source of forest fires.

The Vaisala-based NLDN (National Lightning Detection Network) uses mainly time-of-arrival (TOA) sensors to determine the position of the lightning strike. The precise time at each site is determined using a GPS receiver and claims a positional accuracy of 1/2 km. This accuracy allows operations — such as aircraft refueling — to continue until the last minute.

The Canadian extension (CLDN) to the NLDN added 81 stations to this network in 1998. Two-thirds of the Canadian stations are of the simpler TOA type and one-third are IMPACT sensors (Improved Performance Combined Technology). The IMPACT sensors have both a TOA sensor and direction finding loops. The addition of direction finding stations allows the total number of stations in the network to be minimized. For more details, check out the FAQ under lightning at **www.Vaisala.com**

Ken Devine
Aurora, Ontario, Canada

Cool Websites!

Sub Station Alpha is a freeware program for real time video titling, subtitling, and karaoke.
www.backupdvd.info/Editing

Supercapacitor design calculator in Excel.
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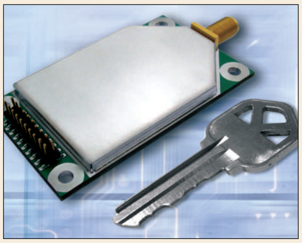
SECURE 1 WATT WIRELESS



Last month's New Product announcement for Maxstream's 9XTend wireless transceiver contained the incorrect website address. The correct website has a .net suffix rather than .com

MAXSTREAM, INC.
Email: **9XTend@maxstream.net**
Web: **www.maxstream.net**

DSO TROUBLESHOOTING WITH A 250 MS/SEC SAMPLING RATE

Technicians and engineers may offer different opinions on circuit layouts, but most will agree on the use of a digital oscilloscope for testing and troubleshooting. For general-purpose testing, a combination of performance versus price is the 6810 series of digital oscilloscopes from Protek Test & Measurement. The 6810 series includes well-designed instruments with eight-bit vertical resolution and 250 msamples/s real time sampling rate.

Both feature an analog bandwidth of DC to 100 MHz with better than 3.5 ns risetime. Voltage amplitude sensitivity can be adjusted from 2 mV/div to 5 V/div. The oscilloscopes perform measurement sweeps at rates of 2 ns/div to 50 s/div in a 1-2-5 sequence. Waveforms are displayed as a function of time with 40 ps standard resolution. In addition to showing voltage amplitude as a function of time, the 6810 series can show the frequency components of a captured signal via a built-in Fast Fourier Transform (FFT) function. Optionally, extension modules are furnished for RS-232C and GPIB interfaces. An automatic zoom function from 1:1 to 100:1 permits close-up views of a waveform display. Prices start at $1,177.00 — a savings up to 20% over competitive brands. Probes, line cords, and manuals are furnished with each instrument. Delivery is from stock through Protek's nationwide distribution network. For more information, contact:

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Circle #87 on the Reader Service Card.

applications), the GTT is the first device that can be safely installed on the ground line in order to eliminate one of the common causes of crashes, lock-ups, and system degradation — ground transients.

Unlike conventional suppression techniques that protect only the AC line, the GTT incorporates a patented circuit with no moving parts or sensitive electronics and — as a result — does not pose any threat to the intrinsic safety ground.

In sensitive micro-electronics, ground transients are one of the most frequent problems and can cause significant disruption in the operation of microprocessor-based equipment. Microprocessor circuits are constantly measuring logic voltages against the "zero voltage reference" or ground and its decision is the result of discrimination of one rapid voltage transition from another, making ultra-clean and quiet electrical grounds essential. Current microprocessors expect to see less than .5 volts of neutral to ground and future innovations will soon lead to designs using voltages near .3 volts. If a microprocessor sees more than .5 volts, operational problems may occur that cannot be duplicated or explained.

The GTT works by opposing changes in electron flow on the ground wire. Its ability to oppose the electron flow slows the damaging rise and fall time of a power surge rather than clipping it off entirely. By doing so, it controls frequency rather than amplitude and keeps damaging voltages from entering.

Possible hobbyist projects for the GTT include data protection on computers, ham radio operations, home theater entertainment systems, robotics, security, and video systems — basically protecting any microprocessor-based electronic device to ensure the utmost in reliability, clarity, and quality of performance.

The GTT offers a wide frequency range of 50 kHz to 2.0 GHz with a fast response time for both current and voltage rise. The standard operating temperature range is -40° to 85° C. The device measures 65 x 55 mm and retails for $99.90.

For more information, contact:

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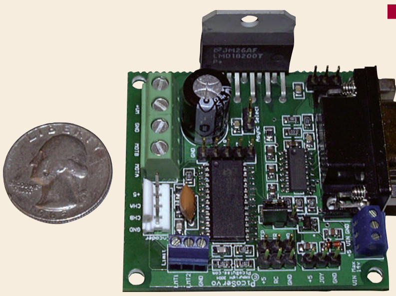
DC SERVO CONTROLLER



The new Pico*Motion*™ from PicoBotics, Inc., is among the smallest and most feature-rich DC brushed motor controllers on the market. With 11 modes of operation, the end user is sure to find a mode for any application. Quadrature encoders of up to 2,048 CPR are supported.

Some of the features include; 1x, 2x, 4x encoder decoding, 12 trapezoidal profiles, 10 PID settings, current monitoring and reporting, analog control, R/C control, RS232 and TTL serial control with any combination of the above.

With data logging and upgradeable firmware, this small board (2" x 2") is the biggest commotion in motion control. Pico*Motion* includes Pico*Talk*™ setup and servo tuning software for Windows®.

The operating range is from 12 to 50 volts at currents of up to 3 A, continuous (6 A, surge). Pico*Motion* costs

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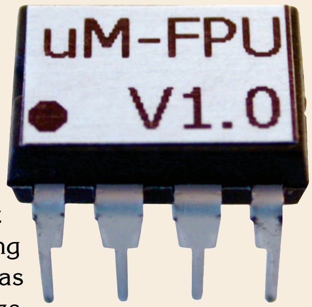
Circle #123 on the Reader Service Card.

uM-FPU FLOATING POINT COPROCESSOR



Micromega Corporation announces the uM-FPU Floating Point Coprocessor. The uM-FPU interfaces to virtually any microcontroller using a SPI interface, making it ideal for applications requiring floating point math — such as converting sensor readings, robotic control, data manipulation, and other embedded control applications.

The uM-FPU provides support for 32-bit IEEE 754 compatible floating point operations and 32-bit integer operations.

A PIC-compatible mode is also available to support PIC format floating point numbers. An extensive list of functions are built-in, including floating point math, long integer math, exponential functions, trigonometric functions, data conversion, and formatting functions. A built-in debug monitor is available to assist in developing and debugging code.

A unique feature of the uM-FPU is the ability to define user functions. User functions are defined as a series of built-in operations and are stored in Flash memory on the uM-FPU chip.

Since they are stored internally, the majority of communications overhead is eliminated. This results in dramatic speed improvements and greatly reduced code space requirements on the microcontroller. Software is provided to define user functions using standard math expressions and to program the uM-FPU over an RS-232 connection.

Documentation and software is provided to support a wide variety of popular microprocessors. The uM-FPU is available in an eight-pin DIP or a 20-pin SSOP package at a price of $14.95, with volume discounts available.

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by Peter Best

The Ever-Shrinking µC

Six Pins and One MIP — If You Can See It!

This Month's Projects

The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included in each article on any special tools or skills you'll need to complete the project.

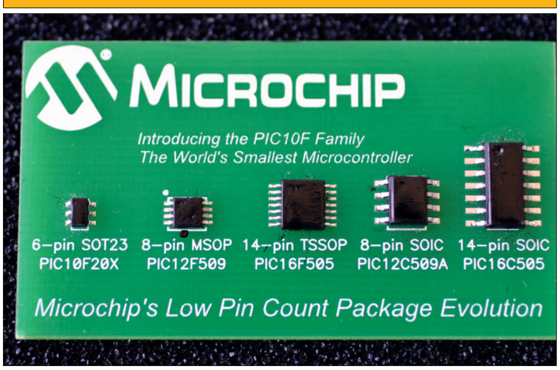
Let the soldering begin!

As you might imagine, I spend lots of my time reading technical books and electronic journals. Recently, to cut the ice, I've been reading about the exploits of men who flew and crewed B-17 bombers for the Eighth Air Force in World War II. If you recall your history, the flyers of the "Mighty Eighth" had one of the highest casualty rates in the war. Why? Because they were doing something that had never been done before.

On a daily basis, these men braved high altitude cold, bad weather, anti-aircraft fire, enemy fighters, and mid-air collisions with their own bombers to attempt to put their thin-skinned aircraft, tons of aviation gasoline, and bombs over a predetermined ground target in broad daylight.

Electric flying suits (a precursor to electric sleeping blankets), wool-lined flying jackets and shoes, and oxygen were essential to the survival of the crews while on their dangerous missions. I'm not going to take you flying on a B-17, but — like the B-17 flyboys — we will today be doing something no one else has done. Snap up that flight jacket and take a deep breath from that oxygen mask because — for the rest of this article — you will be breathing pure oxygen at high altitudes. We're going to fly some highly technical missions on Little Bits, which is powered by a pair of PIC10F206 engines.

***Figure 1**. Yep, the PIC10F206 is a tiny bugger, but it's still big enough to allow you to hang some wire-wrap wire off of its pins or solder it onto a set of SOT-23 copper pads.*



The PIC10F20X Family of Microcontrollers

The PIC10F206 is the largest of the tiniest microcontrollers in the world. The PIC10F200 and PIC10F204 microcontrollers contain 256 words of program Flash and 16 bytes of SRAM. The PIC10F202 and PIC10F206 microcontrollers are loaded with double the program Flash of the PIC10F200 and PIC10F204 microcontrollers (512 bytes) and contain eight more bytes of SRAM (24 bytes).

The differentiator of the same-sized variants of the PIC10F20X family is the addition of an onboard comparator found in the PIC10F206 and PIC10F204 silicon. Both the PIC10F206 and PIC10F204 comparator modules are governed by an internal absolute voltage reference with all comparator inputs and outputs visible on their respective multiplexed I/O pins. The output of the comparator can also be configured not to be shown on the microcontroller I/O pin.

Each PIC10F20X microcontroller has four multiplexed I/O pins, which include three bi-directional I/O pins (GP0, GP1, and GP2) and one input only pin (GP3) when all of the I/O pins are configured for general-purpose I/O mode. All of the GPIO (General-Purpose Input Output) pins except GP2 can be configured with weak pull-ups and wake-up on change operation. Each I/O pin can source or sink 25 mA, which results in a total of 75 mA that can be sourced or sunk by the PIC10F20X microcontroller's I/O port.

Thus, the PIC10F20X family of microcontrollers can directly drive small resistive loads and LEDs.

Clocking for the PIC10F20X microcontrollers is provided internally. A 4 MHz internal clock supplies 1 µS instruction cycles that drive the PIC10F20X's processing engine. The internal clock is factory calibrated and is accurate to ±1%. Cycles from the internal clock can be used to drive the PIC10F20X's on-chip eight-bit timer. The eight-bit timer can also be configured to be driven externally via

the T0CKI pin (GP2) or from the output of the comparator. Like the rest of Microchip's PIC microcontrollers, the PIC10F20X series also includes an integral WDT (Watchdog Timer), program Flash code protection, ICSP (In Circuit Serial Programming) capability, and sleep mode.

The typical PIC10F20X is very similar logically to the PIC12F508 and PIC12F509 microcontrollers, but — as you can see in Figure 1 — the PIC10F20X is a much smaller beast. With only four I/O pins, one would wonder what could be done with such a miniscule microcontroller. Take another deep breath — we're going up ...

Little Bits

Even though the PIC10F20X microcontrollers are tiny, there is no reason why the average Microcontroller Joe can't put them to use. Believe it or not, you can actually solder some wire-wrap wire to each of the PIC10F20X's six pins and breadboard the little bugger just like you would any other electronic part. On the other hand, you could also put together a specialized PIC10F20X printed circuit board that would include a regulated +5 VDC power source, an ICSP socket, and some LEDs with a breadboard

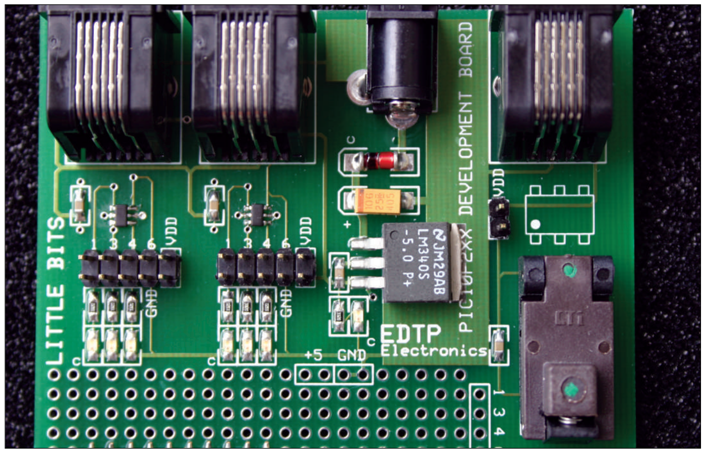
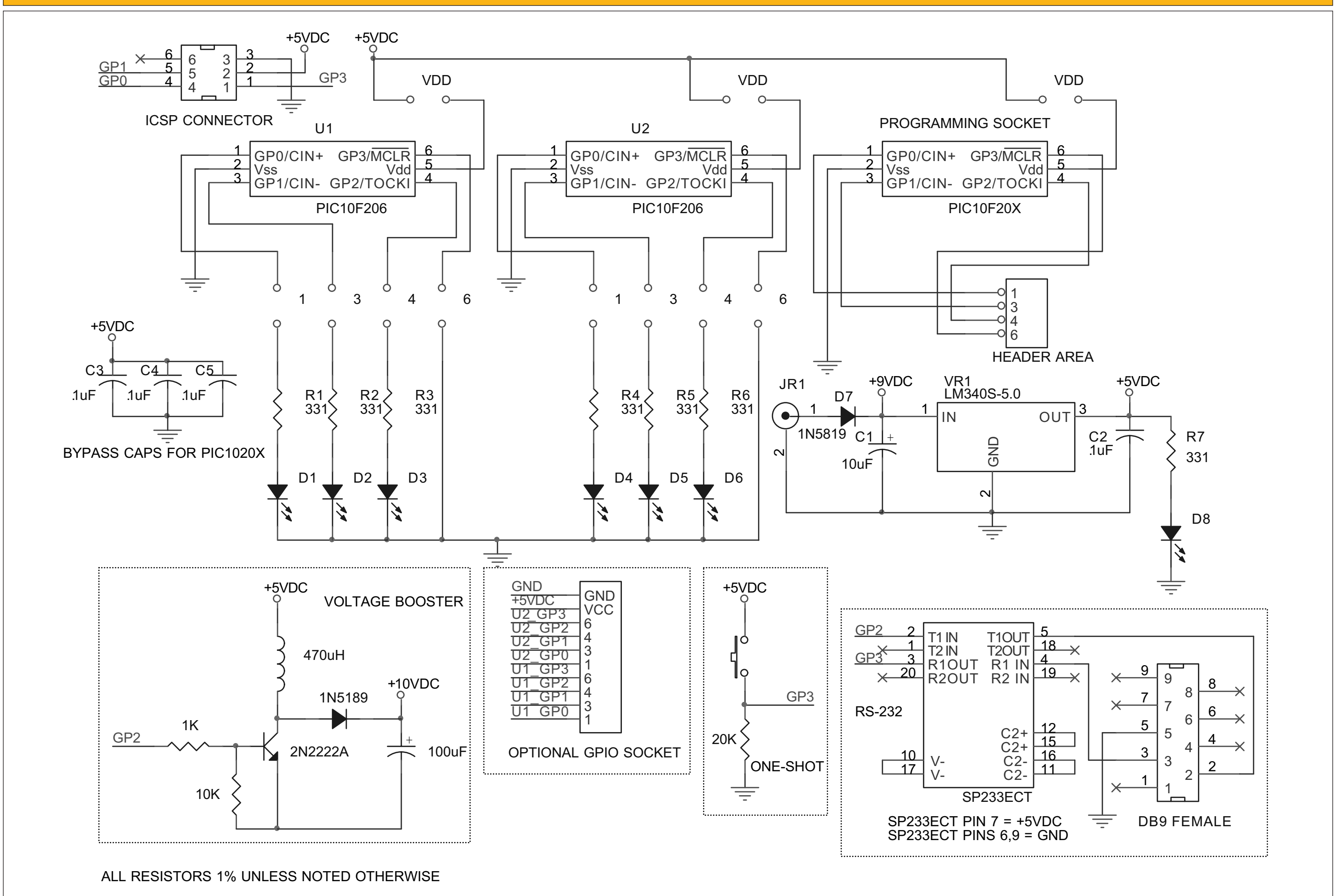


Figure 2. Little Bits is a combination of a regulated 5 VDC power supply and a pair of PIC10F206 microcontrollers. A third PIC10F206 can be programmed and run from the Wells-CTI SOT-23 programming socket position. Two banks of jumper-selectable LEDs are included to free you from having to pull out that logic probe. This photo also shows the dual-row 20-pin female header I added to allow easy access to the pair of Little Bits' PIC10F206 microcontrollers.

Figure 3. The ICSP connector in the schematic is common to all of the PIC10F20X microcontrollers. Jumper blocks allow for easy configuration of the Little Bits microcontrollers.



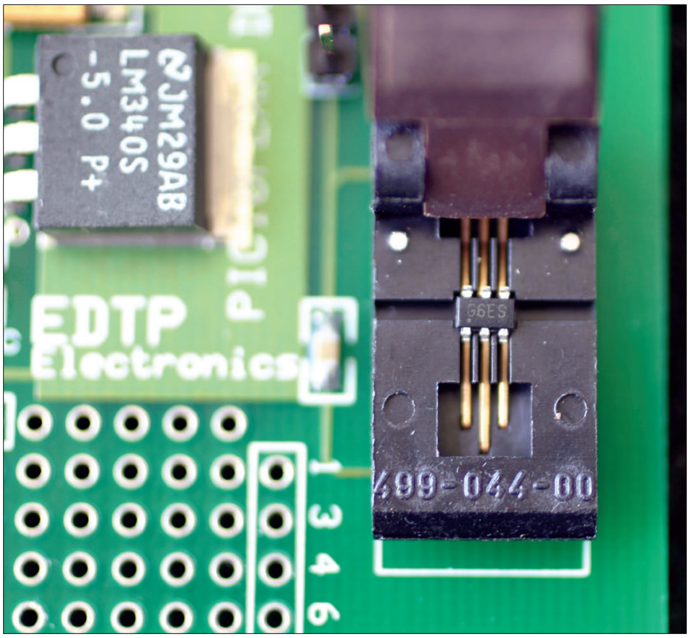


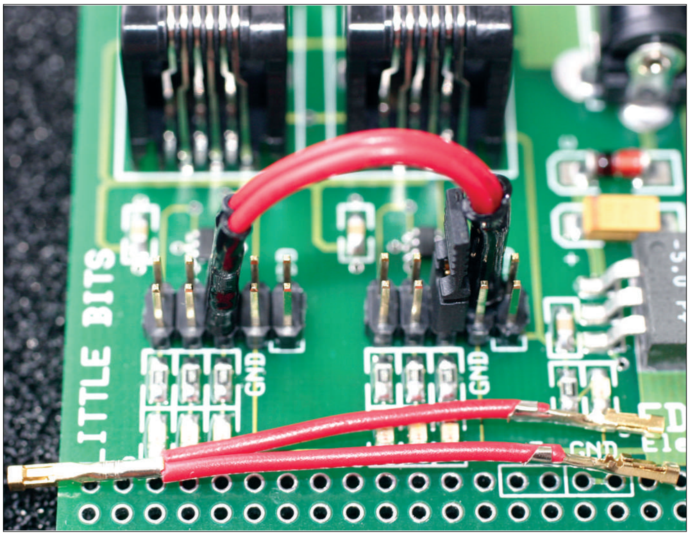
Figure 4. This is a view of a PIC10F206 in the jaws of the Wells-CTI programming socket. The orientation of the PIC10F20X parts inside the programming socket is silk screened on the Little Bits printed circuit board, just above the programming socket.

area. I went with Plan B and assembled the dual PIC10F206-based development board you see in Figure 2. The design you're looking at in Figure 2 is called Little Bits and it can program and run up to three PIC10F206 microcontrollers simultaneously.

As you can see in Figure 2, Little Bits is the classic implementation of the PIC10F206 microcontroller. Two of the PIC10F206 microcontrollers can be directly attached to Little Bits' onboard banks of LEDs via standard .1 inch jumper pin sets. There may be situations where you may not wish to run all of the PIC10F206 microcontrollers at the same time. So, power to each individual PIC10F206 is controlled by a VDD jumper, which also allows quick individual PIC10F206 or PIC10F20X power-on resets, depending on which PIC10F20X you have in the programming socket.

Speaking of programming sockets ... For those who need to program a PIC10F20X for use in an external circuit, Little Bits is equipped with a Wells-CTI SOT-23 programming socket and a third ICSP interface. The Wells-CTI socket position can also be used as yet another PIC10F20X hardstand, as the PIC10F20X I/O pins for the Wells-CTI position are brought out to a header pin area on the Little Bits Development Board. Take a close look at Figure 4 to get a view of the mechanics behind the Wells-CTI programming/burn-in socket.

Figure 5. The Y connector is pulling a signal from GP2 of the PIC10F206 running the TOGGLER program and feeding it into the input pin (GP3) of the PIC10F206, emulating an inverter. The two points of the Y allow the viewing of the source logic level changes. The PIC10F206 inverter's output is GP2 and is jumpered to an LED for easy viewing of the inverter output logic state changes.



Little Bits' Logic

The PIC10F206 was designed to be a utilitarian microcontroller that can stand in for standard logic ICs, generate and manipulate clocks, and perform small, programmable tasks. With some help from the HI-TECH PICC PIC10F20X C compiler, Microchip's MBLAB, and a Microchip MPLAB ICD 2, I'll show you how easy it is to apply some logic with the PIC10F206 and Little Bits.

Before we begin to code our Little Bits microcontrollers, there are some things on the hardware honey-do list that we need to finish up. As you can see in Figure 3, the two banks of LEDs that are common to the pair of permanently mounted PIC10F206s are separated from the PIC10F206's I/O pins by a jumper connection. To be able to see what state each particular I/O pin is in requires a jumper between the I/O pin and its respective LED. The problem is that, when an LED is connected to an I/O pin using a jumper block, there is no way to get the signal to and from the I/O pin/LED combination, as the jumper block is obscuring the I/O pin interface.

To circumvent that problem, I came up with a little Y connector that consists of a couple of pieces of standard hook-up wire terminated with three .025 inch square female terminal post pins (Jameco part number 100765CX). The idea is to connect the PIC10F206 I/O pin to the LED with the double point of the Y jumper assembly and feed or receive the I/O signal with the single point of the Y jumper assembly. To keep the Y cable points from coming into electrical contact with each other, I added a bit of shrink tubing to each of the exposed points of the Y connector. Y connectors with and without shrink tubing and their uses are shown in Figure 5.

Since I'm not pushing a single application here, we'll be adding auxiliary supporting hardware as we gain altitude with our PIC10F206 projects. So, rather than

overload the Little Bits breadboard area, I added a dual-row 20-pin, .1 inch-spaced female connector (Jameco part number 70826) to my Little Bits to allow the association and disassociation of external hardware that is fitted with a matching set of dual-row male .025 inch header posts. This will come in handy when we teach the PIC10F206 to control external devices and communicate with the outside world.

PIC10F206 as an Inverter

Let's begin by casting the PIC10F206 as an inverter: the simplest of which is a 7404 or 74XX04, where XX can be HC, LS, etc. The typical logic inverter is a two-pin device that consists of an input and a complementary output. Since we have four I/O pins on a PIC10F20X, we can implement up to two inverter modules per microcontroller. So, let's choose GP3 — the input-only I/O pin — as our inverter #1 input and GP2, a bi-directional I/O pin, as our inverter #1 output.

The reason for choosing GP3 is rather obvious. The reason I chose GP2 as the output is because I can leave the MPLAB ICD 2 connected to Little Bits and still see the inverter code function via a LED patched into the GP2 output pin. The latest version of MPLAB IDE includes the ability to reset the target PIC and release the reset to the target PIC from within the MPLAB IDE. Therefore, I can write my C code, program the PIC10F206, and start and stop the PIC10F206's code execution all from the same MPLAB IDE window.

Every bit of code you'll see from now on will be C with a HI-TECH PICC flavor. The HI-TECH folks are way ahead of the curve

Listing 1. Chances are you'll never need to inspect the assembler code that the HI-TECH PICC C compiler generates. My purpose of showing it to you here is to point out how good the assembled C code really is.

```
//*********************************************************************
//*  HI-TECH C SOURCE CODE FOR INVERTER MODULE
//*********************************************************************

#include <pic.h>

__CONFIG(MCLRDIS & WDTDIS & UNPROTECT);

void main()
{
 TRIS = 0b11111011;      //GP2 = output : GP3 = input
 FOSC4 = 0;              //GP2 = I/O pin
 CMCON  = 0b11110111;    //comparator off
 OPTION = 0b11001111;    //pull-ups and wake-up off

 while(1)                //loop forever
 {
  if(GPIO & 0b00001000)  //look for a high on GP3
   GP2 = 0;              //GP3 was high
  else
   GP2 = 1;              //GP3 was low
 }//while(1)
}//main

//*********************************************************************
//*  RESULTING ASSEMBLER FROM HI-TECH C COMPILER
//*********************************************************************
                                        processor       10F206
                                        opt     pw 79
                                        psect   __Z18698RS_,global,delta=1
                                        psect
ctext0,local,size=512,class=ENTRY,delta=2
                                        psect   config,global,class=CONFIG,delta=2
                                        psect
text0,local,class=CODE,with=ctext0,delta=2
                                        psect   text1,local,class=CODE,delta=2
                                        psect   __Z18698RS_
        008
        008                             ;#

                                        psect   config
        3FF   FEB                       dw      4075     ;#

                                        psect   text0
        1F1                       _main
                                      ;inverter.c: 33: TRIS = 0b11111011;
        1F1   CFB                       movlw   -5
        1F2   006                       tris    6
                                      ;inverter.c: 34: FOSC4 = 0;
        1F3   405                       bcf     5,0
                                      ;inverter.c: 35: CMCON = 0b11110111;
        1F4   CF7                       movlw   -9
        1F5   027                       movwf   7        ;volatile
                                      ;inverter.c: 36: OPTION = 0b11001111;
        1F6   CCF                       movlw   -49
        1F7   002                       option
                                      ;inverter.c: 38: while(1){
        1F8                       l3
                                      ;inverter.c: 39: if(GPIO & 0b00001000)
        1F8   766                       btfss   6,3      ;volatile
        1F9   BFC                       goto    l5
                                      ;inverter.c: 40: GP2 = 0;
        1FA   446                       bcf     6,2
                                      ;inverter.c: 41: else
        1FB   BF8                       goto    l3
```

(continued ...)

(Listing 1, continued)

```
    47  1FC                         l5
    48                                ;inverter.c: 42: GP2 = 1;
    49  1FC  546                          bsf      6,2
    50                                ;inverter.c: 43: }
    51  1FD  BF8                          goto     l3
    52
    53                                    psect    text1
    54  0000

HI-TECH Software PICC Macro Assembler V8.05
Symbol Table                                             Fri Aug 20 13:44:07 2004

          l3 01F8            l5 01FC          _main 01F1          start 0000
```

and at this writing have the only fully functional PIC10F20X compiler — C or BASIC. You may be asking yourself why I'm using C when assembler would be more compact and efficient. If you are indeed asking yourself this question, you're in for a surprise — breathe deeply and pull back the stick.

The C rendition of our PIC10F206 inverter code is shown in its entirety in Listing 1. The #include <pic.h> statement brings in all of the predefined names and locations that the HI-TECH PICC C compiler needs to associate the names and locations in our C source code to the PIC10F206 hardware. In fact, the pic.h include files bring in a specific set of definitions for the PIC10F206, which is defined in the very first line of the HI-TECH PICC C compiler-generated assembler listing. The __CONFIG statement sets up the PIC10F206 fuses. If you've ever written any PIC assembler, the only unfamiliar parameter is MCLRDIS, which configures the GP3 line as an I/O input. Otherwise, GP3 doubles as the MCLR pin.

The beginning of our inverter C code simply turns off all of the PIC10F206 frills and sets the PIC10F206's internal muxes to configure all of the PIC10F206's four I/O pins as GPIO. All of the inverter's working code lies between the while(1) braces. The while(1){} construct forms an endless loop. Within the endless loop, we are simply looking at GP3 and toggling GP2 in the opposite logical direction of what we see at GP3.

I've also provided the assembler listing that is generated by the HI-TECH PICC C compiler. I've eliminated the line numbers that did not contain any useful information for our discussion. The HI-TECH PICC C compiler collects like kinds of data in what are called psects or program sections. Without going into great detail, lines 3-7 and 18 define the psects. It's a logical process and you can see the names and types of program sections in the actual assembler code that are defined within the initial psect statements.

The HI-TECH PICC C compiler linker uses the psects to group like kinds of data into their appropriate memory areas of the PIC10F206. For instance, code in the psect text0 and psect text1 areas is placed in the PIC10F206's ROM (program Flash) area. Note that configuration fuse data is located in the CONFIG psect. Don't get too wrapped up about psects, as we're going to let the compiler automatically handle them for the PIC10F206.

Take a look at the very last line of Listing 1. You'll notice that the locations of labels l3 and l5 are listed. Also, note that the actual program code is placed into the PIC10F206 program memory, beginning at physical address 0x1F1, which is logically program location 0x0000. That may seem odd, but the HI-TECH PICC C compiler purposely puts things where they are for efficiency.

You've seen the mnemonics shown in the assembler listing beginning at _main in your own PIC assembler programs. Note that the binary numeric arguments in the C source are treated as negative 2's complement binary numbers in the assembler source statements. When using signed binary arithmetic, the most significant bit is used as a sign bit with 1 signifying a negative number and 0 indicating the number is positive. For instance,

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0b11111011 is the 2's complement representation of -5. If that is true, then the negative number 2's compliment rule states that — if I invert every bit within 0b11111011 and add 1 — I should be able to add the inverted result of the original number (0b00000101 or +5) to the original number (0b11111011 or -5) and end up with 0. Let's try that:

```
   11111011     original
+  00000101     flipped + 1
  100000000
```

What's up with that? My TI Voyage 200 in binary mode indicates the same answer, which is decimal 256. Remember, we're only working with eight bits. The carry of a 1 out to the ninth bit indicates that the result of the binary addition is positive. In this case, the binary addition result of 0 (0b00000000) is considered positive. No carry out of the ninth bit would leave the most significant bit at 1, indicating a negative result.

Let's get back to how the inverter code operates. The inverter assembler code is very tight. The C source statements are followed by their assembler counterparts. Do you think you could have written the assembler code from scratch any better than the C compiler did? For those of you who nodded your heads yes, let's add that second inverter.

The dual-inverter C source in Listing 2 is quite a bit different than our simple single inverter code. GP0 has been assigned as the input for Inverter #2 with GP1 acting as the inverter #2 output. The rest of the code is simply looking at GPIO and testing for every possible logical combination of the input pins: GP0 and GP3. The result of the switch (GPIO & 0b00001001) statement determines which case statement will execute. All

Listing 2. It would defeat the purpose of using C, but you could actually write your application in C and then look at the generated assembler to figure out how to write that same application more efficiently with assembler.

```
//***********************************************************************
//*  HI-TECH C SOURCE CODE FOR DUAL INVERTER MODULE
//***********************************************************************
void main()
{
 TRIS = 0b11111001;              //GP3 = input #1 : GP2 = output #1
                                 //GP0 = input #2 : GP1 = output #2
 FOSC4 = 0;                      //GP2 is an I/O pin
 CMCON  = 0b11110111;            //comparator off:pullups off:wakeup off
 OPTION = 0b11001111;            //prescaler assigned to WDT

 while(1)                        //loop forever
 {
  switch(GPIO & 0b00001001)
  {
   case 0b00000000:              //inverter #1 input = LOW
    GP1 = 1;                     //inverter #2 input = LOW
    GP2 = 1;
    break;
   case 0b00000001:              //inverter #1 input = LOW
    GP1 = 0;                     //inverter #2 input = HIGH
    GP2 = 1;
    break;
   case 0b00001000:              //inverter #1 input = HIGH
    GP1 = 1;                     //inverter #2 input = LOW
    GP2 = 0;
    break;
   case 0b00001001:              //inverter #1 input = HIGH
    GP1 = 0;                     //inverter #2 input = HIGH
    GP2 = 0;
    break;
   }//switch
 }//while(1)
}//main

//***********************************************************************
//*  RESULTING ASSEMBLER FROM HI-TECH C COMPILER
//***********************************************************************
     1                                   processor      10F206
     2                                   opt     pw 79
     3                                   psect   __Z18698RS_,global,delta=1
     4                                   psect
ctext0,local,size=512,class=ENTRY,delta=2
     5                                   psect   config,global,class=CONFIG,delta=2
     6                                   psect
text0,local,class=CODE,with=ctext0,delta=2
     7                                   psect   text1,local,class=CODE,delta=2
     8                                   psect
temp,global,ovrld,class=BANK0,space=1,delta=1
    19                                   psect   __Z18698RS_
    20   00C
    21   00C                             ;#
    22
    23                                   psect   config
    24   3FF   FEB                       dw      4075     ;#
    25
    26                                   psect   text0
    27   1D8                       _main
    28                               ;dual_inverter.c: 52: TRIS = 0b11111001;
    29   1D8   CF9                       movlw   -7
    30   1D9   006                       tris    6
    31                               ;dual_inverter.c: 53: FOSC4 = 0;
    32   1DA   405                       bcf     5,0
    33                               ;dual_inverter.c: 54: CMCON = 0b11110111;
    34   1DB   CF7                       movlw   -9
```

(continued ...)

(Listing 2, continued)

```
  35  1DC   027          movwf   7        ;volatile
  36                   ;dual_inverter.c: 55: OPTION = 0b11001111;
  37  1DD   CCF          movlw   -49
  38  1DE   002          option
  39                   ;dual_inverter.c: 57: while(1){
  40  1DF   BF6          goto    l6
  41                   ;dual_inverter.c: 58: switch(GPIO &
0b00001001)
  42  1E0              l7
  43                   ;dual_inverter.c: 59: {
  44                   ;dual_inverter.c: 61: GP1 = 1;
  45  1E0   526          bsf     6,1
  46  1E1   BE3          goto    L1
  47                   ;dual_inverter.c: 62: GP2 = 1;
  48                   ;dual_inverter.c: 63: break;
  49  1E2              l8
  50                   ;dual_inverter.c: 64: case 0b00000001:
  51                   ;dual_inverter.c: 65: GP1 = 0;
  52  1E2   426          bcf     6,1
  53  1E3              L1
  54                   ;dual_inverter.c: 66: GP2 = 1;
  55  1E3   546          bsf     6,2
  56                   ;dual_inverter.c: 67: break;
  57  1E4   BF6          goto    l6
  58  1E5              l9
  59                   ;dual_inverter.c: 68: case 0b00001000:
  60                   ;dual_inverter.c: 69: GP1 = 1;
  61  1E5   526          bsf     6,1
  62  1E6   BE8          goto    L2
  63                   ;dual_inverter.c: 70: GP2 = 0;
  64                   ;dual_inverter.c: 71: break;
  65  1E7              l10
  66                   ;dual_inverter.c: 72: case 0b00001001:
  67                   ;dual_inverter.c: 73: GP1 = 0;
  68  1E7   426          bcf     6,1
  69  1E8              L2
  70                   ;dual_inverter.c: 74: GP2 = 0;
  71  1E8   446          bcf     6,2
  72  1E9   BF6          goto    l6
  73  1EA              l30004
  74  1EA   20A          movf    btemp+2,w
  75  1EB   643          btfsc   3,2
  76  1EC   BE0          goto    l7
  77  1ED   F01          xorlw   1
  78  1EE   643          btfsc   3,2
  79  1EF   BE2          goto    l8
  80  1F0   F09          xorlw   9
  81  1F1   643          btfsc   3,2
  82  1F2   BE5          goto    l9
  83  1F3   F01          xorlw   1
  84  1F4   643          btfsc   3,2
  85  1F5   BE7          goto    l10
  86                   ;dual_inverter.c: 75: break;
  87  1F6              l6
  88  1F6   206          movf    6,w      ;volatile
  89  1F7   E09          andlw   9
  90  1F8   02A          movwf   btemp+2
  91  1F9   06B          clrf    btemp+3
  92  1FA   20B          movf    btemp+3,w
  93  1FB   643          btfsc   3,2
  94  1FC   BEA          goto    l30004
  95  1FD   BF6          goto    l6
  96
  97                     psect   text1
  98  0000
 136                     psect   temp
```

(continued ...)

of the possible logical combinations of the inverter pair outputs are found within the four case statements.

The assembler code for our dual inverter is a bit more hairy, as well. The big picture is that the code immediately jumps to label l6 and gathers the states of the inverter input pins. The code then jumps to label l30004, where the inverter logic is performed. Depending on the outcome of the logic computation, the program then jumps to the appropriate case statement — beginning at label l7 — and sets the inverter pair output pins.

I've taken the liberty of placing the compiler build output at the bottom of Listing 2 to show you where everything is located within the PIC10F206. Note the psect temp and the reservation of four bytes of memory beginning at SRAM location 0x008. Do you still think you can write better assembler code than that produced by the HI-TECH PICC C compiler? If you're still nodding yes, you had better turn on that electric flying suit. We're gaining altitude.

I think you have the idea now. You're all checked out on the PIC10F controls and we're flying level. That flight suit is pretty warm right now, but I don't want your feet to get cold. So, go aft and find that pair of wool-lined flight boots because, next time, we're going to be gaining even more altitude. So far, we've looked at the PIC10F, a hardware platform called Little Bits, the HI-TECH C Compiler that drives them, and an inverter application.

Next time — as we pull the yoke back — we'll fly through coding a two-input and three-input AND gate. I'll also describe how to construct various other logic gates using the PIC10F microcontroller. When we've flown through logic gate altitude, I'll show you how to code a D FLIP-FLOP. The air will be thin, but we'll keep climbing and

write some PIC10F pulse generation code. When you think the contrails can't get any thicker, pull out that Digital Filter Development Board because I'm going to pair it with the Little Bits Development Board to show you how easy it is to code RS-232 routines that run on the world's smallest microcontroller. **NV**

Resources

HI-TECH Software
HI-TECH PICC C compiler
www.htsoft.com

Microchip
MPLAB ICE 2000
PIC10F206
MPLAB IDE
www.microchip.com

EDTP Electronics, Inc.
Little Bits
Digital Filter Development Board
www.edtp.com

(Listing 2, continued)

```
   137   008                           btemp
   138   008                                 ds      4


Psect Usage Map:

Psect     | Contents                     | Memory Range
---------|----------------------------|--------------------
init      | Initialization code          | $0000 - $0000
end_init | Initialization code          | $0001 - $0001
text      | Program and library code     | $01D8 - $01FD
vectors   | Reset vector                 | $01FE - $01FE
temp      | Temporary RAM data           | $0008 - $000B
config    | User-programmed CONFIG bits | $03FF - $03FF

Memory Usage Map:

Program ROM   $0000 - $0001  $0002 (     2) words
Program ROM   $01D8 - $01FE  $0027 (    39) words
                               $0029 (    41) words total Program ROM
Bank 0 RAM    $0008 - $000B  $0004 (     4) bytes total Bank 0 RAM
Config Data   $03FF - $03FF  $0001 (     1) words total Config Data

Program statistics:
Total ROM used        41 words (8.0%)
Total RAM used         4 bytes (16.7%)
```


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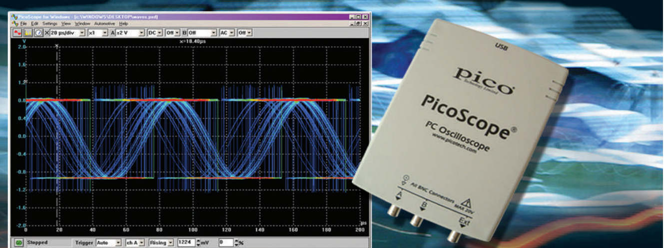

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I have designed this project for photographers who want to activate their cameras from a distance. It can be used for Canon SLR (Single Lens Reflex) cameras, like the Canon EOS66, EOS88, EOS500N, EOS3, EOS33, and the latest digital Canon EOS300D — which is a professional digital camera. The range of this remote is approximately 15 feet.

This project features a simple, small unit and full-use capabilities for arial, wildlife, and physically dangerous photography.

There are two components to this project. The first is the transmitter and the second is the receiver. The transmitter is based on the SM5021B IC and the receiver is based on the SM5032B IC. These two ICs are specifically made for infrared media.

Transmitter

Figure 1 is an infrared transmitter for a camera. An SM5021B IC is the heart of the transmitter; this IC is available in 16-pin DIP and SO packages. This little, handy encoder is made for infrared transmission media with 38 kHz generated internally.

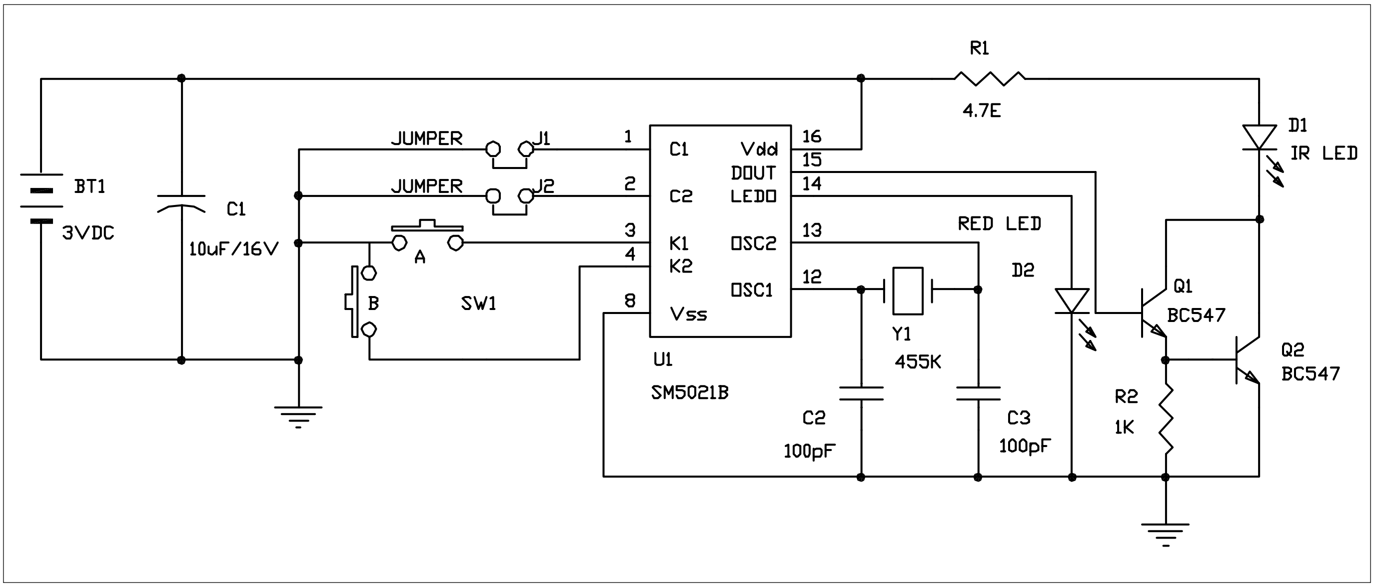
Circuit BT1 has a 3 VDC power supply. Two AA or AAA batteries can be used. C1 is a supply filter; J1 and J2 are jumpers that are used to set the code for the product. SW1 is a double action switch; this special switch is mainly made for camera applications. It is not easily found, but a link to a supplier is provided. C1, C2, and Y1 resonate to internally generate the 38 kHz oscillator. D2 is a 5 mm LED, which indicates the transmission.

Q1, Q2, and R2 drive the infrared LED, and R1 limits its current. Figure 2 shows the circuit configuration for the double action switch and shows how the switch works.

Receiver

Look at Figure 3 to see the receiver. TSOP1738 is a miniature 38 kHz infrared receiver for remote control applications, R1 is to control the current to U1, and C2 is the power supply filter. Q1, R3, and R2 are for inverting the data coming from U1. U2 is the SM5032B decoder.

Figure 1. Schematic of the IR transmitter.



C3 and R5 are the internal oscillators. D1 is a 5 mm, green LED for supply indication. R4 is the current limiting resistor for the LED. R7, Q2, R6, and Q3 drive the internal LED of the photomos relay. R8 and R9 are current limiting resistors for the photomos relays and the internal LEDs.

U3 is a photomos relay with two switches inside. The internal circuit of the photomos relay is shown in Figure 4.

Here, you may want to use electromechanical relays, but there will be some problems. It will draw more current and the response time will be too slow.

To avoid all these problems, I have used a photomos relay because the camera will be completely isolated from the remote receiver. It's also small and has a great response time.

How It Works

The function of the circuit is very simple. A half-press of the first switch (A) will drive SM5021B pin 3 low. The IC will

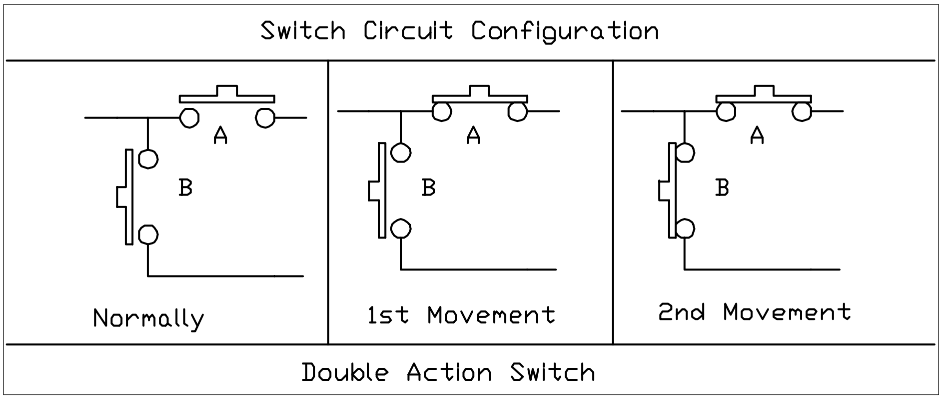


Figure 2. Behavior of the double action switch.

Links for Components Sourcing

IR RX Vishay Data Sheets
www.vishay.com/docs/82030/82030.pdf

Infrared LED
www.vishay.com/docs/81006/81006.pdf

www.vishay.com/docs/81008/81008.pdf

www.fairchildsemi.com/parametric/results.jsp?command=eq&attr1=Product+Category&attr2=:Optoelectronics:Infrared:Emitting+Diodes:&render=1

Double Action Tact Switch
www.singatron.com/SWITCH/SWITCH/

KTL.pdf
www3.alps.co.jp/indexpdf_switches-e.html

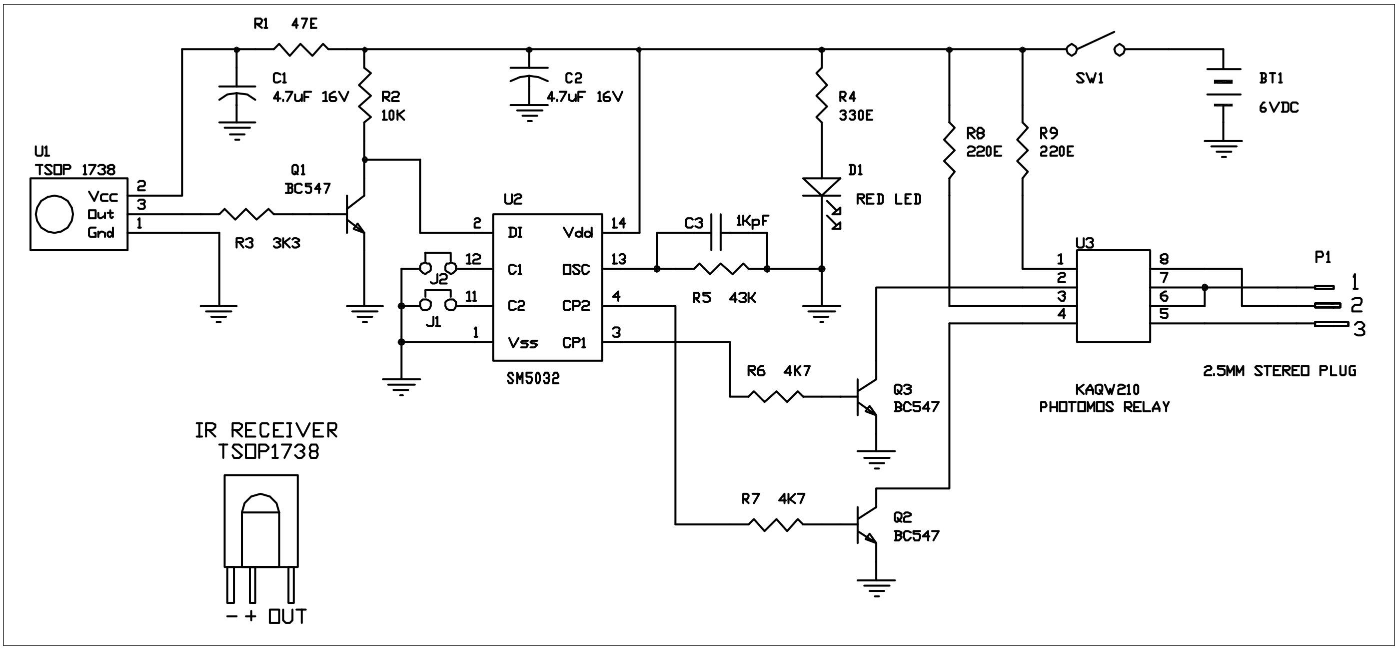
Photo MOS Relay
www.cosmo-ic.com/pdf/Kaqw210.pdf

www.crydom.com/pdf/G2-Dual_Form_A.pdf

2.5 mm Stereo Plug
www.amabilidade2002.com/plugsjacks16.htm

Encoder/Decoder (SM5021B, SM5032B)
www.samhop.com.tw/home.htm

Figure 3. Schematic of the IR receiver.



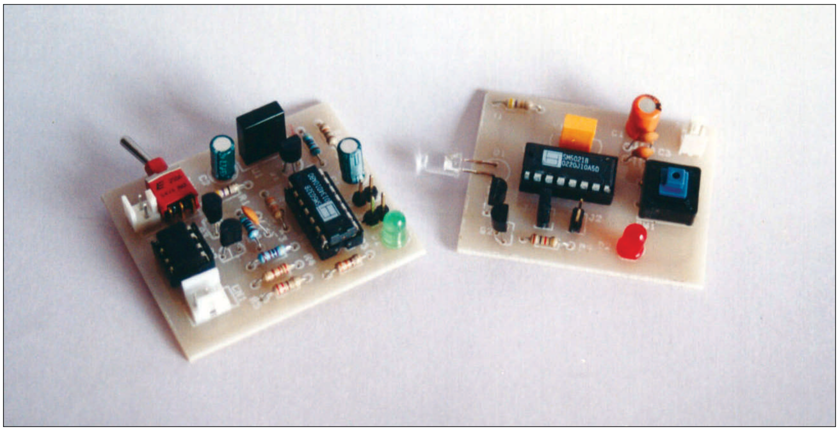


Figure 4. The completed prototypes.

transmit the data with a 38 kHz carrier.

At the receiver, TSOP1738 will receive the data, demodulate and feed it to Q1. Q1 will invert the data and feed it to IC SM5032B, which will compare the code from the jumper setting. If the jumper setting is the same, it will give a high pulse to Q3, Q3 will switch on the internal LED of the photomos relay, and the other side of the relay — between pins 7 and 8 — will be shot. It will set the focus and aperture of camera and — when you completely press the switch, SW1 (B) — this will drive pin 4 of SM5021B low and the same receiver will get the data. SM5032B pin 4 will be high and it will switch on Q3 and cause the LED of the photomos relay to glow. The other side of the photomos relay — pins 5 and 6 — will also be shot and the shutter will fire.

So, basically, when you half-press the camera's button, this will set the aperture and focus; when you completely press the switch, the camera will fire. **NV**

About the Author

Rajkumar Sharma can be reached at raj079@yahoo.com or raj@sharmafesco.com

Parts List

Transmitter Parts

R1	4.7 Ω 1/4 W
R2	1K 1/4 W
C1	10 µF 25 V electrolytic
C2, C3	100 pF disc
U1	SM5021B decoder
Q1, Q2	BC547 NPN transistor
D1	IR LED, Vishay TSAL4400
D2	5 mm red LED
Y1	455 kHz resonator
BT1	Two AA or AAA batteries
J1, J2	Jumper
SW1	Double action switch

Receiver Parts

R1	47 Ω (all resistors are 1/4 W)
R2	10K
R3	3.3K
R4	330 Ω
R5	43K
R6, R7	4.7K
R8, R9	220 Ω
C1, C2	4.7 µF 25 V
C3	1,000 pF disc
U1	PIN diode, Vishay TSOP1738
U2	SM5032B
U3	KAQW210 photomos relay
Q1-Q3	BC547 NPN transistor
D1	5 mm red LED
P1	2.5 mm stereo plug
Battery	Four AA or AAA batteries
J1, J2	Jumper
SW	ON/OFF switch

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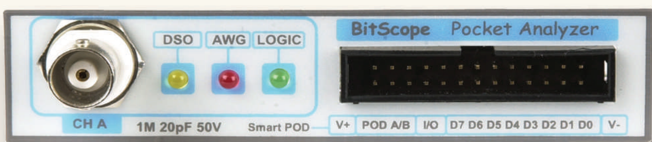

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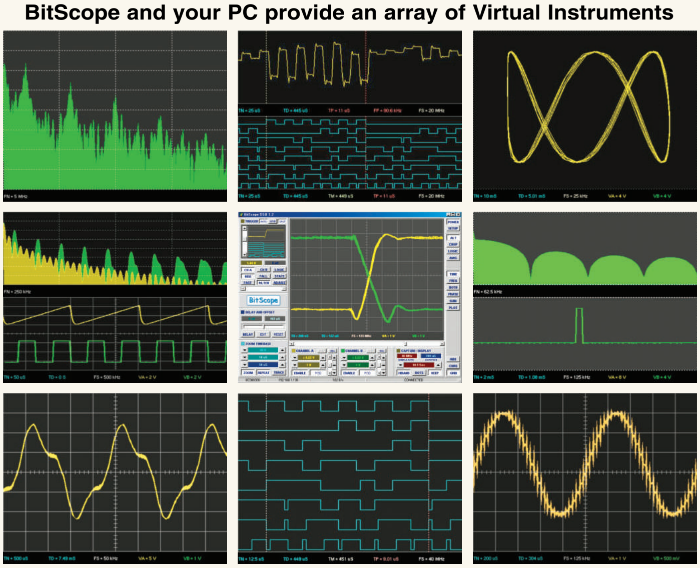

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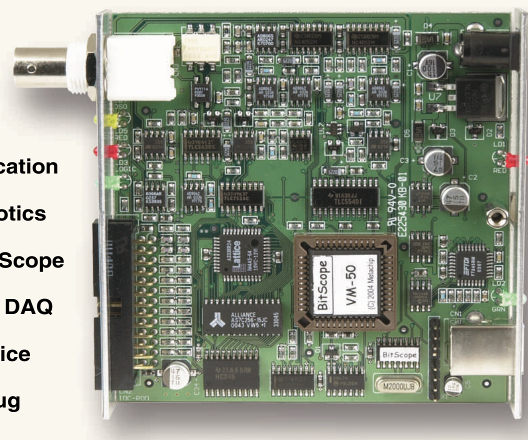

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by Craig Sellen

Build the Muscle Whistler

Listen to the "Tone" of Your Biceps

There are 656 muscles in the human body and all of them generate a small voltage potential when they are activated. This voltage — which is called myoelectricity or EMG — is present on the surface of the skin surrounding the muscle. The detection of this signal is important in both clinical medicine and medical research.

Reaction time, for example, can be measured by noting the time lag between a stimulus and the onset of EMG activity. Audible EMG monitoring has been used experimentally in training athletes, on animals, etc. (Note: Do not test the Muscle Whistler on pets or other animals.) It has been hypothesized that athletes can learn complicated, coordinated muscle skills faster by listening to their muscles during training.

The Muscle Whistler — described here — can monitor many of the muscles in the body, producing a whistling tone each time a muscle is activated.

Try it, for instance, with the electrodes on the biceps muscle (upper arm) while lifting a heavy object. Signals can also be picked up with the electrodes on the triceps (back of upper arm) when you try to push something. The flexor muscles (on the front of the lower arm) are active when you clench your fist and the gastrocnemius muscle (in the calf) is active when you stand on your toes. You may be surprised to hear muscle activity even when you think a muscle is relaxed. This is called "muscle tone" and is characteristic of all muscles.

Whether you listen to the Muscle Whistler to monitor the force generated by your muscles, measure your reaction time, or improve your golf swing, this project will provide an entertaining introduction to an important area of medical electronics.

Theory of Circuit Design

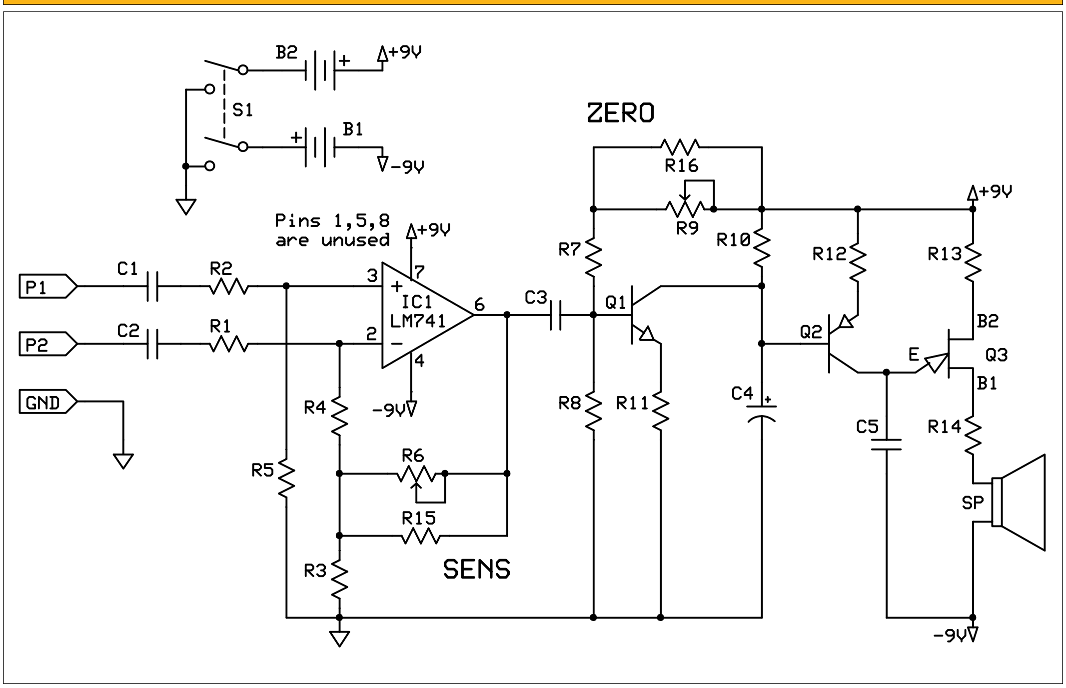
Operational amplifier IC1 is a very high gain differential amplifier whose gain (sensitivity) is controlled by feedback potentiometer R6, R15. The differential input to the op-amp is picked up by the electrodes applied to the skin.

Unijunction transistor Q3 is wired in the classical UJT oscillator configuration with capacitor C5 determining the frequency and the emitter-collector resistance of Q2 (with limiting resistor R12) acting as the charging resistor. The interelement resistance of Q2 is a function of the applied base current and the voltage to move this current is stored in capacitor C4, which is charged up by amplifier Q1. The size of the steady-state charge on C4 is determined by the settings of potentiometers R9 and R16.

When a muscle voltage is amplified by IC1 and fed to Q1, the collector voltage on Q1 varies, thus changing the charge on C4.

This, in turn, varies the UJT oscillator frequency. The speaker and R14 form the load for Q3 and the audible

Figure 1. Schematic of the Muscle Whistler.



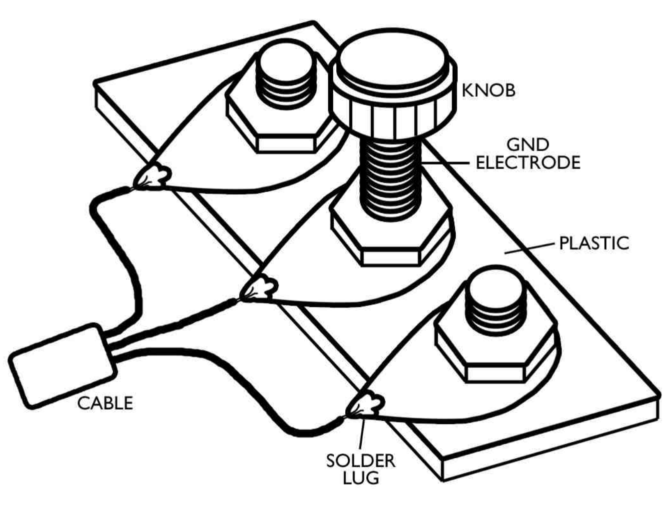


Figure 2. Typical electrode mounting scheme.

tone consists of a series of spikes, each occurring as the UJT fires.

Construction

The circuit of the Muscle Whistler is shown in Figure 1. The prototype was built on a piece of perf board, though any other method may also be used. The components are either mounted on small clips or the leads may be soldered directly underneath the board. A 14-pin dual in-line socket that is only half used may be used for the IC, if desired. The input connector (J1), the speaker, the zero and sensitivity potentiometers (R9 and R6, respectively), and the on-off switch (S1) are mounted on the front panel of the selected chassis box. A conventional three-lead microphone jack with an associated three-lead microphone connector and a few feet of three-lead cable are used to connect the muscle electrodes to the circuit.

The electrodes are fashioned from two screws, mounted 3 or 4 inches apart on a narrow piece of plastic, as shown in Figure 2. A third screw — midway between the other two — forms the ground electrode. Solder lugs under the nuts are used to connect the three color-coded leads from the circuit. The center screw is longer than the other two so that a knob or handle can be attached.

Operation

With power applied to the circuit, adjust R9 so that there is no output from the speaker when there is no input signal. The output varies from a whistle down to a series of slow clicks. Adjust R9 until the clicks just stop. When the sensitivity control, R6, is turned up slightly, touching one of the end electrodes on the muscle probe should cause the circuit to squeal due to an imbalance in the op-amp

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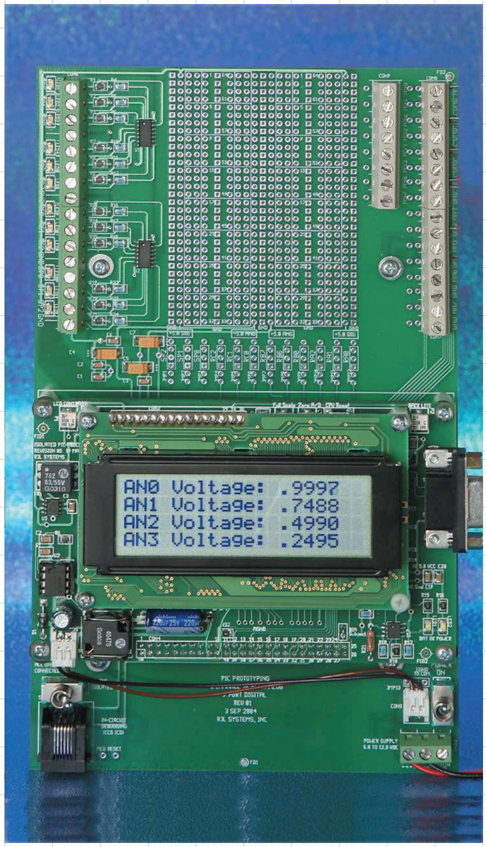

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circuit. (It is actually picking up the field created by the 60 Hz power line.)

However, when both electrodes are touching the skin, virtually all of this ambient noise is rejected by the differential amplifier.

Make sure that good electrical contact is made between the electrodes and the skin. Use a commercial electrode paste or make your own by mixing salt, water, and flour into a pasty consistency. The paste is rubbed into the area of skin where the electrodes are to be applied.

Before the electrodes are placed against the skin, partially set R6 up and be sure R9 is adjusted to give no output. Then, place the electrodes against the skin. There will be a change in the tone of the output. Adjust R9 just below the oscillation point and adjust R6 until the output changes frequency as the muscle is activated. Each time the muscle is flexed, the whistle changes frequency. The tenser the muscle, the higher the frequency is; the more relaxed the muscle, the lower the frequency will be. **NV**

Parts List

R1-R3	10K
R4, R5	1M
R6, R9	500K potentiometer
R7	330K
R8	33K
R10	27K
R11, R12	1K
R13	470 Ω
R14	91 Ω
R15, R16	510K
C1-C3, C5	0.1 µF disc
C4	5 µF 16 V electrolytic
IC1	741N op-amp
Q1	2N3904
Q2	2N3906
Q3	2N4870 or 2N4871 (available from Mouser Electronics at **www.mouser.com**)
B1, B2	9 V battery
J1	Three-pin microphone connector and plug
S1	DPST switch
SP	8 Ω speaker

Misc: battery connectors, battery mounting clips, knobs, IC sockets (optional), three lead cables or two lead cables with ground shield, plastic strip for electrodes, solder lugs, electrode hardware, conducting paste, perf-board, etc.

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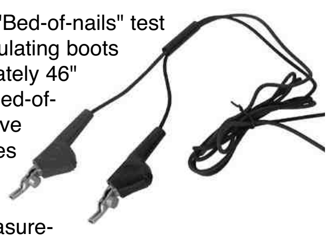

J.S. Popper "Bed-of-nails" test clips with insulating boots on approximately 46" long leads. Bed-of-nails clips have multiple spikes in the middle of the clip enabling measurement through insulated wire. The jaws at the front of the clip grab and hold securely to plugs or terminals. The leads are stranded copper litz wire with red and black woven cloth insulation. Leads were cut from new equipment and may require a crimp terminal to facilitate attachment. **CAT# ALG-22**

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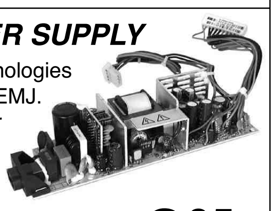

Mineba, NMB Technologies Corp# MS001A096EMJ. Replacement power supply for Microsoft Xbox, v. 1.0-1.1. Open-frame supply, 8.25" x 2.55" x 1.55" high. UL, CE. **CAT# PS-96**

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Digital R/C Airplane Camera

Aerial Digital Photography in a Snap

I've always been interested in photography and, when I first saw an advertisement for a "key chain digital camera," I had to get one. In fact, I got two, since they were inexpensive and so small that I figured I would lose one.

After playing with them for a while, I decided to see if I could get one to fit into a park-flyer electric R/C airplane or model rocket. The size and weight of the camera were suitable, but it was designed to operate in your hand, not remotely or automatically. Since I only had $25.00 invested in the camera, I set about dissecting it to turn it into a sequence camera.

Why Digital?

I have seen R/C airplanes modified to carry video cameras and transmitters, but — if you don't absolutely need to have full motion video — a digital camera has a few advantages.

First, power consumption is lower, since the digital camera stores the data rather than transmitting it, although the camera burns through AAA batteries pretty quickly. In addition, there are no concerns about the video transmitter interfering with the airplane's control receiver. Second, the image resolution is higher — 640 x 480 pixels versus the typical 320 x 240 pixels for video cameras. Third, there's no degradation of the digital image, as you might experience with a transmitted video signal.

Finally, if your landing is non-survivable, the replacement cost of the digital camera is low.

Hacking the Camera

To turn your digital camera into a sequence camera, first remove the battery cover and the stickers inside the battery compartment.

Next, pry off the clear plastic panel on the front of the camera that covers the display and the camera lens (it is held on with double-sided tape). Remove the screw under this panel and then gently pry apart the front and rear halves of the case.

Once inside the case, remove the screw holding the mounting bracket for the key chain and discard the entire assembly, then remove the two screws holding the circuit board to the case.

Finally, remove and discard the view finder assembly, since it won't be needed and just adds weight.

Observe the "top" side of the circuit board with the LCD and the camera lens (Figure 1). On the upper-left side of the board is the shutter switch with two leads; momentarily grounding the right-hand lead causes the camera to capture an image. Solder a wire to this lead with a fine-tipped soldering iron, making sure not to bridge the solder to adjacent components or the switch body. Solder a ground wire to one of the large solder

Figure 1. Modifications to the shutter switch.

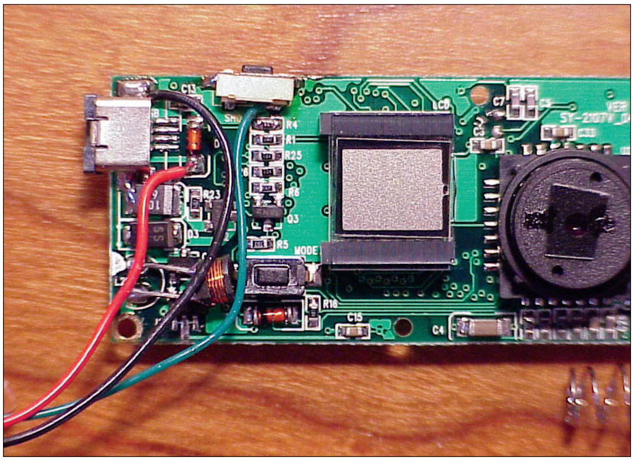
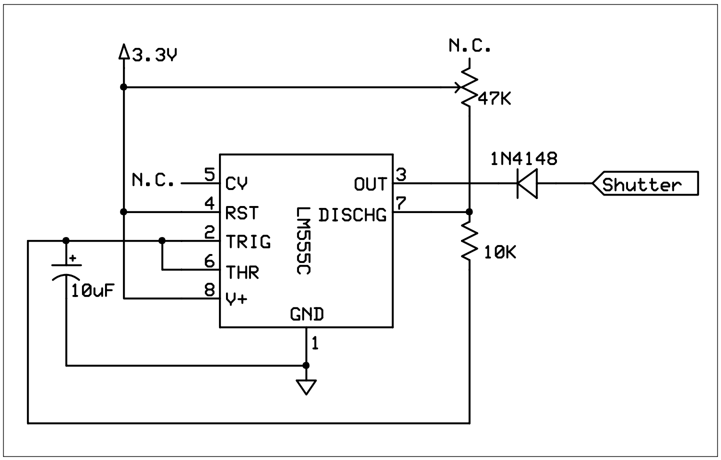


Figure 2. CMOS 555 timer circuit.



pads that holds the USB connector body to the circuit board.

Also in the upper-left corner of the board is a glass diode — just to the right of the USB connector. The cathode (banded) end of the diode is connected to the positive supply voltage, so solder a wire there to power the timer circuit. Route the three wires out of the hole where the key chain mounting bracket used to be and reassemble the camera case. You may want to leave the clear plastic front panel off to save weight.

Figure 3. Moving parts in the plane to make room.

In addition, you may want to place a piece of polarizing film over the lens to cut down on glare from water or the sun itself.

The Timer Circuit

Figure 2 shows a simple CMOS 555 timer circuit that outputs a short, negative-going pulse at an adjustable interval of several seconds to trigger the camera's shutter. The CMOS part's wide supply voltage range is needed for this application more than its low power consumption, since the camera operates on 3.3 volts internally via a voltage-doubler circuit.

Diode D1 is included as a precaution to prevent unwanted interactions between the timer and the camera. Solder the power supply, ground, and pulse output connections from the timer circuit to the corresponding wires from the digital camera and fabricate some sort of enclosure to prevent the circuit from shorting against any adjacent parts inside the airplane. (If you're handy with surface mount parts, you may be able to build this circuit inside the camera body.)

Pop the AAA battery into the camera and press the "Mode" switch on the front once. The display should show "26" and, after a few seconds, the camera should beep as it takes its first picture; the display should now show "25." Set the interval between pictures to whatever you desire by adjusting the variable resistor in the timer circuit.

For Your Info

*The best place to find an inexpensive key chain camera changes all the time. The best thing to do is just type "key chain digital camera" into the Google search engine at **www.google.com***

Figure 4. An actual image from a flight!

Modifying the Aircraft

The airplane I have is an entry level, three-channel electric model called an Aerobird. It's my first plane and has demonstrated remarkable durability, considering its

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purchase price (which was low) and my piloting skills (also low).

It also has a fair amount of space in the fuselage, which is filled with Styrofoam blocks that hold the battery pack in place. By moving the battery forward as far as it will go and fabricating a smaller Styrofoam block to hold it in place, the camera will fit snugly on its end on the port side of the fuselage, behind the battery, with the wires and timer circuit on top (Figure 3). Make a hole in the fuselage opposite the lens so the camera can see out and make another hole opposite the "Mode" button so you can turn on the camera once you're ready to take off.

For other types of R/C aircraft, the modifications should be similar. If you have space, installing the camera horizontally rather than vertically is preferable. Just make sure the camera can't slide around and has a clear view out of the fuselage.

I Can See My House From Here!

I advise that you become proficient at flying whatever plane you end up installing the camera in prior to taking your first aerial photography flight. Be prepared to trim the pitch and yaw, since the camera will change the center of gravity of the plane; you may want to pre-trim the plane before flight if you know its flight characteristics well.

Once you've landed, extract the camera and turn it off to save battery power, then download the photos. Depending on your camera's orientation in the plane, you may have to rotate them with image editing software so that up is really up. Then you can enjoy the view from a few hundred feet, such as this picture of a reservoir near my house (Figure 4).

Advanced Camera Controller

I plan to build a more sophisticated control circuit for the camera based on an eight-pin PIC microcontroller. This circuit would control both the "Mode" button and the shutter, allowing the camera to perform any of its functions while in flight. This opens up the possibility of using the camera's video capture feature to take an 8 second video at a predetermined time and also to have the camera turn itself off after its memory is full.

Now just sit back, relax, and enjoy your flight (pictures, that is)! **NV**

Parts List

- CMOS 555 timer
- 1N4148 diode
- 47K potentiometer
- 10K resistor
- 10 μF capacitor

Author Bio

Dan Gravatt is a licensed geologist with the State of Kansas. He can be reached at dgravatt@juno.com

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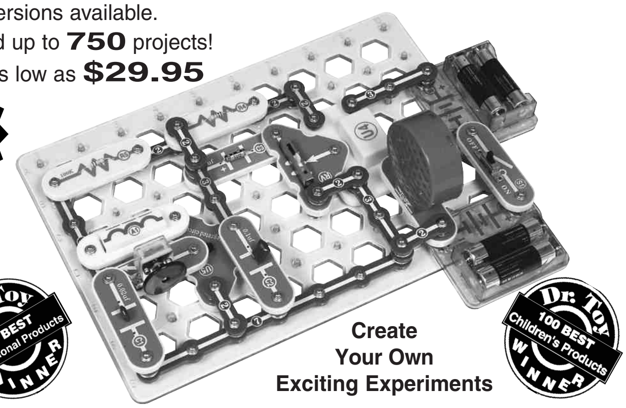

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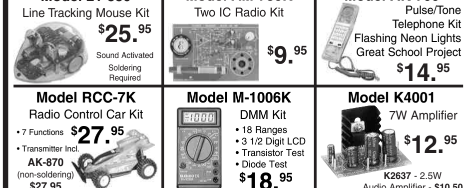

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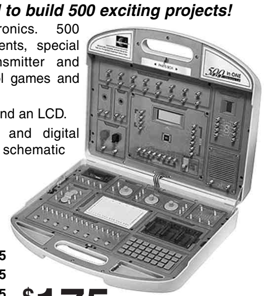

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by Dave Siegel

Garage Parking Assistant

Simple Circuit Monitors Door Sensors

Looking for an easier way to park your car or truck in the garage? Read on.

Parking vehicles accurately in a standard-sized garage requires judgment, experience, and a little bit of guesswork. In my own case, there isn't enough room to walk in front of my van if I pull it in too far. If I don't pull in far enough, the rear bumper of the van will block the garage door's closing path. This has been a challenge for several years.

Background

There are some low tech answers out there. One example is a tennis ball suspended from the garage ceiling, positioned to rest on the windshield when the vehicle is properly parked. Another example is placing ridged mats on the floor to enable you to "park by feel." I was looking for something more high tech. I decided to use my electronics knowledge to come up with something to do the job better.

This article will describe a "higher tech" solution that has been operating in my garage for several months. It has proven itself to be very helpful when I'm parking vehicles in the garage. The circuit monitors the signals sent from the photoelectric safety sensors — those two little boxes connected to the garage door opener that "sense" when the closing path of the garage door is blocked.

Government safety requirements dictate that some form of emergency garage door reversing method be included on all garage door openers sold in the US. Photoelectric sensors are the most common method in use. These sensors are mounted on either side of the garage door opening and are there to prevent injuries from a closing garage door by reversing the downward travel of the door if a person (or a vehicle) interrupts the photoelectric beam that is projected across the opening.

With the addition of a simple circuit, the sensors can be used to turn on an indicator light when the beam is blocked. This light can be mounted on the wall in front of and in clear view of the driver. During parking, the indicator light switches on and remains on during the time that the advancing vehicle blocks the garage door opening. The light switches off when the rear of the vehicle clears the opening. Stopping the vehicle at this point will leave maximum space in front of the vehicle and ensure clearance of the garage door's closing path. This method is so accurate and repeatable that it takes the guesswork out of parking.

For Your Info

This project has a difficulty rating of 2. Necessary equipment is a multimeter and an oscilloscope. Skills necessary are: basic electronic construction, reading schematics, and using a voltmeter and an oscilloscope.

Genie Sensor Signals

Figure 1. Optical sensor signals from Genie model GXL9550CL garage door opener.

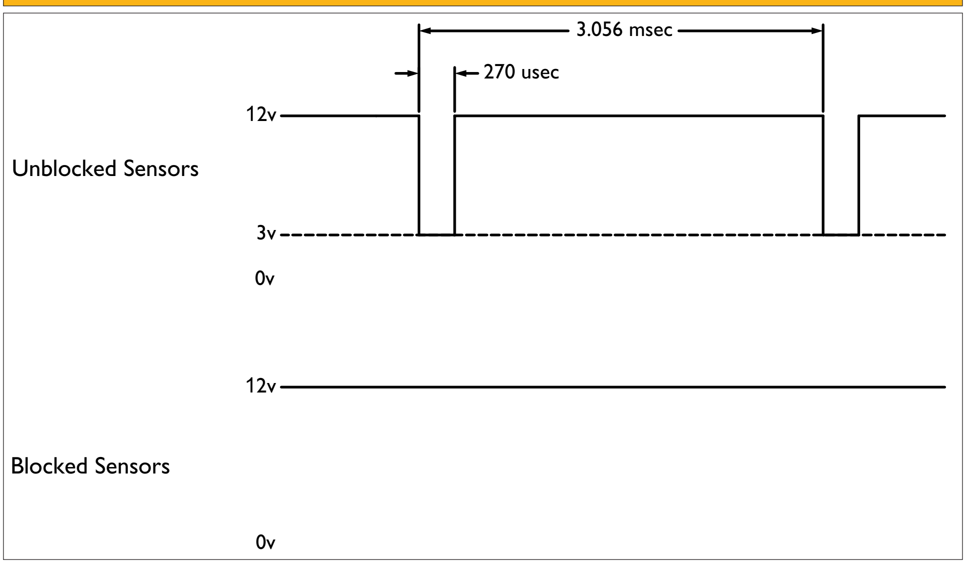


Figure 1 shows the sensor signals from the Genie GXL9550CL garage door opener. On this model, the signals from the sensors can be viewed with a scope on terminals 3 and 4 (ground) of the four terminal strips located on the "power head." The power head is the box that contains the motor from which the rail and screw drive extends.

When the sensors are unblocked, they send a 327 Hz square wave signal with a duty cycle of 91.2% to the power head. The amplitude is from 3 V to 12 VDC. When the sensors are blocked, the signal is forced high to +12 V. The basic function of

the added circuit is to monitor this pulse train and switch the indicator light on when the pulses are forced to +12 volts and switch the light off when the pulses reappear.

This can be accomplished with a "missing pulse detector" circuit driving a relay. This circuit should work with any door opener that has similar sensor signals. Check your own door opener to determine if the sensor signals are similar. The frequency does not have to be exact, as it will be adjusted later.

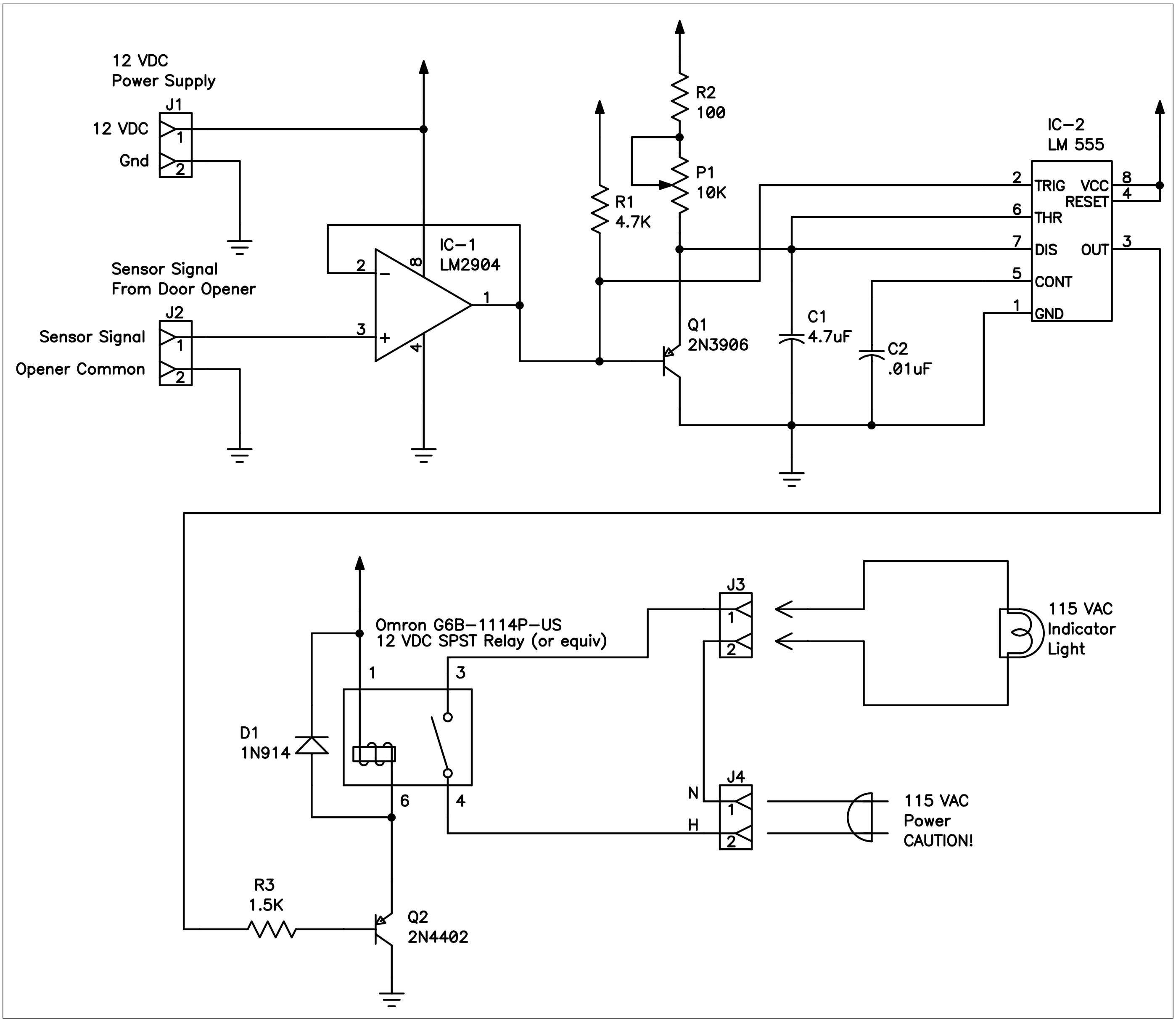
How the Circuit Works

This circuit was designed to work with the Genie model GXL9550CL garage door opener. Before building this project, you should determine whether your door opener sensor signals are similar to those on the Genie. You will need an oscilloscope and the manual for your opener. The manual should have a diagram showing where the door sensors connect to the power head.

Figure 2 shows the schematic of the monitor circuit. The sensor signal from the door opener is connected to J2. (The existing connection of the sensors to the door opener is not removed; this additional connection is merely added.) The sensor signal is fed to IC1, which serves as a high impedance unity gain buffer. This prevents loading of the sensors and also drives transistor Q1.

The missing pulse detector is comprised of Q1, IC2, and associated components. IC2 is set up as a monostable (one shot) multivibrator. P1, R2, and C1 set the time delay of IC2. R2 is there to protect Q1 should potentiometer P1 be

Figure 2. Schematic diagram of sensor monitor circuit.



inadvertently zeroed during set up. The incoming pulses from the door sensors continually discharge C1 before it times out, which continually resets the timing cycle of IC2. This keeps IC2, pin 3, high. When the sensors become blocked, the missing pulses allow C1 to charge fully, completing the timing cycle, and driving output pin 3 low. This provides base drive to Q2, which switches on and energizes the relay coil. The normally open contacts close, switching on the 120 VAC indicator light to signal that the door path is blocked. The indicator light remains lit until the obstruction moves out of the door path and the pulses reappear at pin 3 of IC1.

Parts List

Resistors

R1	4.7K
R2	100
R3	1.5K

Capacitors

C1	4.7 µF
C2	.01 µF

Semiconductors

IC1	LM2904
IC2	LM555
Q1	2N3906 PNP
Q2	2N4402 PNP
D1	1N914

Potentiometers

P1	10K, 10 turn

Relay

12 VDC SPST relay (Omron G6B-1114P-US or equivalent)

Miscellaneous Parts

Project box (Jameco 18905CP or equivalent)
12 VDC @ 250 mA regulated "wall wart" power supply
Perfboard
Two eight-pin DIP sockets
Line cord
Lamp socket
115 VAC light bulb
Four two-pin terminal blocks
Grommets for wires

Circuit Construction

Building the circuit is not complicated and it can easily be constructed on perfboard. I used sockets on the ICs and the relay. You will need access to the set-screw on P1 for adjustment when the circuit is powered-up and connected to the garage door opener. Keep in mind that there will be 120 VAC present on this board at all times, so be especially careful. Double-check all wiring and solder joints. Figure 3 shows the completed prototype board.

Final Assembly

The completed board can be housed in a plastic or metal enclosure. I used a plastic box with slots for the perfboard to slide into, which makes mounting the board much easier. The box requires both 120 VAC and 12 VDC. You can use a 12 volt "wall wart" or a small power supply that will fit inside. Power and signal wires are passed through a grommet-lined hole drilled in the box.

Installation and Set Up

The completed enclosure can be mounted with VELCRO® or double-sided tape at or near the garage door opener. The indicator light can be mounted wherever it can

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be easily seen by the driver(s) while pulling vehicles into the garage. A good location would be on the wall in front of the vehicle(s). Connect 12 VDC and the door sensor signal to the appropriate terminal blocks. Do not connect 120 VAC or the lamp yet.

We have to set the time delay of the 555 timer to slightly exceed the time between the incoming pulses from the door sensors. Verify that the door sensors are unblocked and connect an oscilloscope to the output of the 555 timer (U2, pin 3). Then adjust P1, decreasing its resistance until negative-going pulses appear in the 12 volt output. When the pulses appear, turn the set-screw of the pot in the opposite direction, increasing the resistance until the pulses disappear and the output is high.

Give the set-screw an extra 1/4 turn in the same direction. Connect an ohmmeter across the N.O. relay contact J3, pin1–J4, pin 2. The meter should show infinite resistance. Then block the sensors while watching the scope. The 555 output should go low and the relay should click on. The meter should show a resistance of <1 Ω. Unblock the sensors and the output should go high, clicking off the relay. The resistance should again be infinite.

If it doesn't work this way, go back and check all connections and reheat all solder joints. It is easy to make wiring errors with the PNP transistors if you are used to using NPN type, as I am. Disconnect the test equipment and connect the lamp and the 120 VAC. The circuit is now ready to use.

Adjusting Sensor Height

It may be necessary to adjust the height of the door sensors to properly sense the entire length of all the vehicles parked in your garage. When I tested my prototype, the sensors were too low and the lamp would turn off when the rear wheels of my van cleared the door, but the rest of the vehicle was sticking out. The sensors had to be raised up a bit. Measure the distance from the garage floor to the bumper top and also from floor to the bumper bottom. Then calculate the midpoint of the bumper using this formula: Sensor height = (bumper top + bumper bottom)/2. Do this for all vehicles to be parked in the garage. Use this information to determine an optimum sensor height that will catch the end of both bumpers and move the sensors to this height. Test the system by pulling the vehicles in the garage and noting the point at which the light goes on and goes off. Stop the vehicle at the point the light goes off and verify that the door path is clear. Do this with all vehicles that will be parked in the garage.

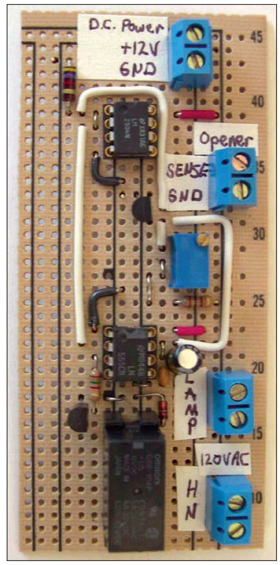

Figure 3. Completed circuit on perfboard.

Conclusion

This device has proved itself invaluable in my garage and I'm sure it will in yours, too. **NV**

About the Author

Dave Siegel is an engineering technologist in the research facility of a "Big Three" automaker in the Detroit area. He holds an Associate's Degree in electronic technology from Schoolcraft College and has attended Lawrence Technological University. His hobbies include electronic projects, ham radio (KF8ID), and bicycling.

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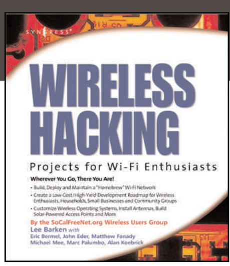

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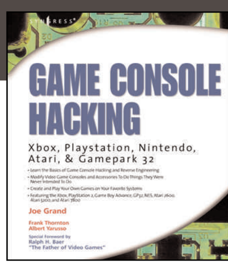

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Circle #100 on the Reader Service Card.

by Michael Kornacker

The Telephone Rang Indicator

Build This Device That Informs You When Someone Has Called Your Telephone

Since I am in and out of my office many times a day, I needed a visual indicator to tell me if someone called and to inform me that I may have a voice mail message.

If I come in after being out and see the LED lit, then I know there is probably a message. If the LED is not lit, then no one called and I don't have to bother checking for messages.

Figure 1 is the schematic diagram circuit of my simple phone rang indicator circuit, which uses only a few easy-to-obtain parts. This circuit will not only light an LED when the phone rings, but will keep the LED latched on after the phone stops ringing until you pick up the handset to check your messages. When you pick up the handset to check your messages, the LED will automatically extinguish and reset the circuit for the next call.

How the Circuit Works

When the phone rang indicator circuit is connected to the phone line, the normal on-hook voltage of 48 volts is applied to the part of the circuit that consists of R1, R2, C1, and Q1. Let's ignore C1 for the moment because it comes into play when the telephone rings, which I'll cover later. The on-hook voltage — applied through the voltage divider circuit of R1 and R2 — turns on and saturates Q1.

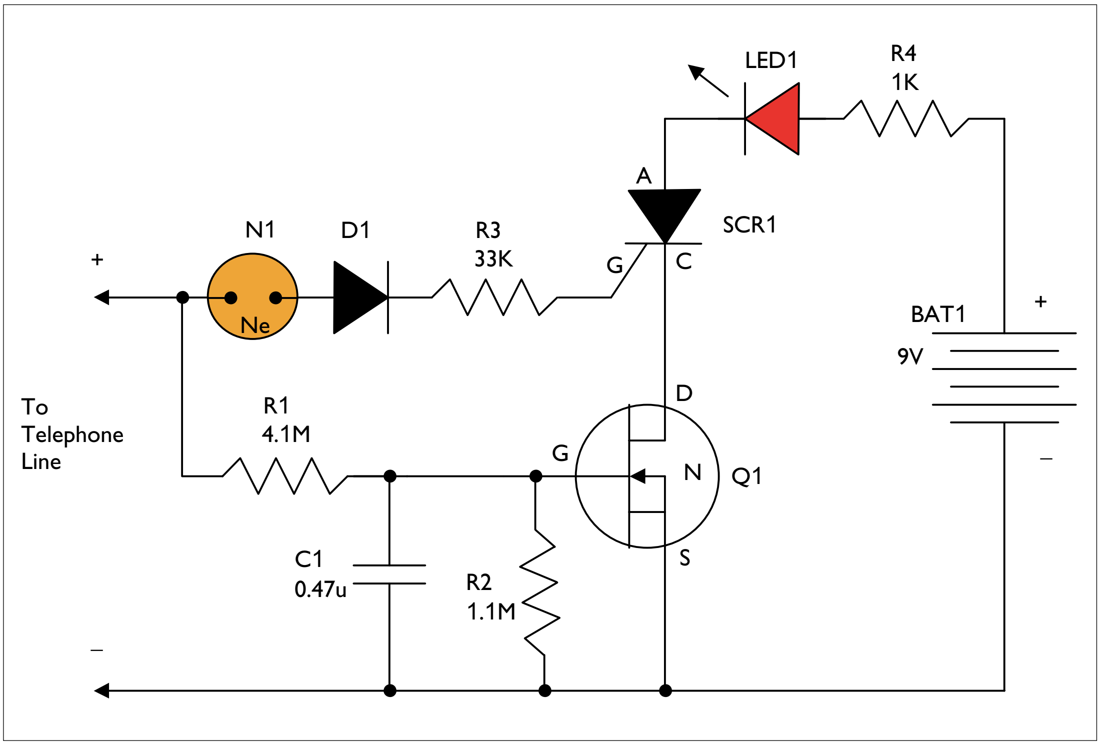
Still in the on-hook state, SCR1 is in the off state, as is LED1, because the DC voltage is blocked by C2. When the telephone rings, about 175 volts of AC ringing voltage appears on the line.

The ringing voltage is rectified by D1 and is coupled through C2 and current limiting resistor R3 to the gate of SCR1. Since Q1 is already on, the ringing voltage will turn on SCR1 and, thus, turn on LED1 through its current limiting resistor, R4, by way of the 9 volt battery, BAT1.

When the telephone stops ringing, C2 stops conducting, but SCR1 will remain latched on. Since the line voltage returns back to the 48 volts DC level, Q1 stays on, and LED1 stays illuminated, telling us that the phone rang.

Now, when we pick up the handset to check our messages, the line voltage goes down to about 10 volts. Through the voltage divider of R1 and R2, the voltage at Q1's gate voltage goes to about 2 volts, which will turn off Q1. If Q1 is off, then

Figure 1. The telephone rang indicator schematic circuit diagram.



SCR1 will turn off and extinguish LED1. Thus, the circuit has automatically reset itself and is now ready for the next call — no need for a manual reset switch.

The last detail of our circuit is C1. It keeps the high voltage ring signal from Q1's gate because a voltage greater than about 20 volts there will damage Q1. C1 and R1 form a 20 Hz low-pass filter and attenuate the 175 volts AC ringing voltage to about a safe 1 volt AC level.

I housed the unit in a RadioShack plastic box from their computer department; it can mount two Category-3 computer jacks. Category-3 jacks work great for telephone service. Make sure that when you connect the device to the telephone line, you observe the polarity shown.

I also found that the battery didn't last too long, so I replaced it with a 9 VDC "wall wart" power supply. Q1 is a little underrated for this application, but I haven't had any problems with it. You could use a part with a 200 volt or higher drain-source rating to be on the safe side.

By the way, this circuit — as far as I know — should meet all FCC (Federal Communications Commission) requirements both for on-hook impedance of greater than 5M (R1 + R2) and for ringing impedance of greater than 30K (R3) and should, therefore, be safe to connect to the telephone system. **NV**

Parts List

R1	4.1 M Ω, 1/2 W
R2	1.1 M Ω, 1/2 W
R3	33K Ω, 1/2 W
R4	1K Ω, 1/2 W
C1	0.47 µF, 200 V
N1	NE-2 neon bulb
D1	1N4004, 400 PIV, 1 amp
Q1	IRF510, 60 V, N-channel MOSFET
SCR1	200 V, 1 amp, silicon controlled rectifier
LED1	Any color LED
BAT1	Standard 9 volt battery
Case	Snap-in 2-port surface-mount box (RadioShack 278-2092)
Two phone jacks	Snap-in module, Category-3 jacks (RadioShack 278-2022)
Phone cord	Two-foot telephone line cord (RadioShack 279-0334)
Perf-board	A small piece of perf-board to mount the components

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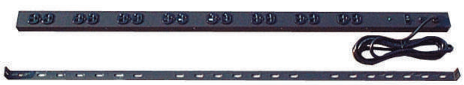

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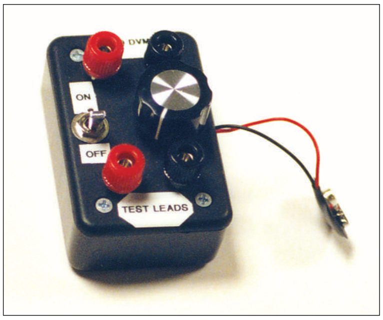
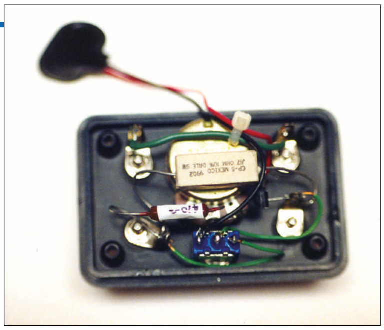
Theory of Zeroing Circuitry

Cancel Out Your DVM Lead Resistance





To measure resistance, a digital ohmmeter uses a constant current source to convert resistance to voltage, which is then read by an A/D converter and displayed as ohms.

In Figure 1, we see a current drive of 1 mA into a 1 ohm resistor, resulting in 1 mV. Thus, on a display of 000.0, the reading would be 1.0. This, of course, assumes there is zero resistance in the test leads.

If the output display did not measure tenths of an ohm, there would be no distinguishable error. For meters showing tenths of an ohm, however, the error can be a problem when making low resistance measurements, as shown in Figure 2.

To overcome this limitation, I have devised an adaptor that is connected between the DVM and its test leads.

Look at Figure 3 to see an isolated 5 V power source that is connected in such a manner as to cancel out the lead resistance error. The current from the meter is diverted though the zeroing source. The zeroing

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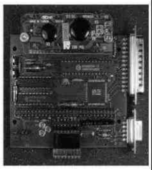

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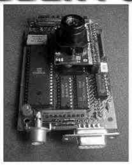

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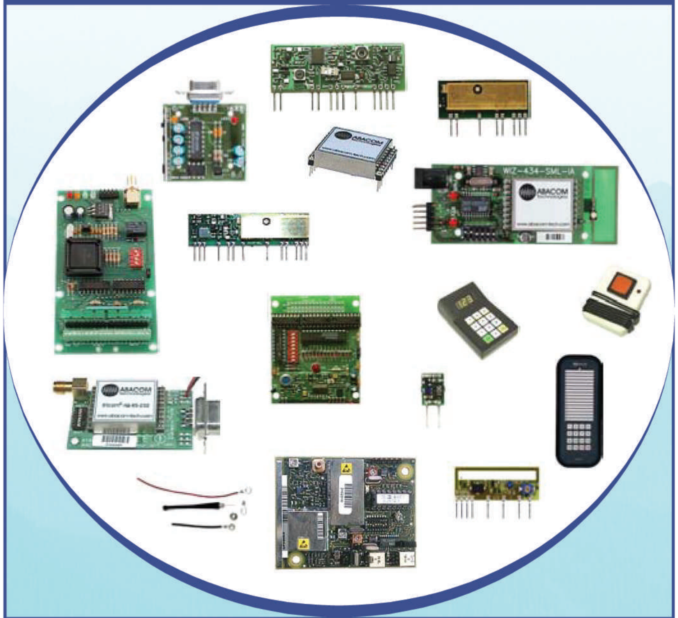

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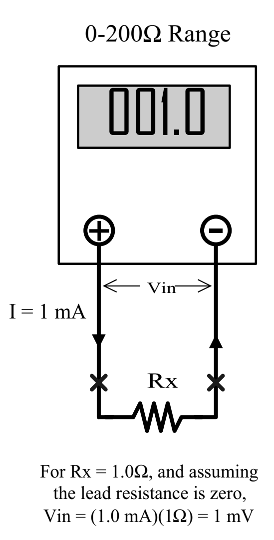


Figure 1. Ideal leads.

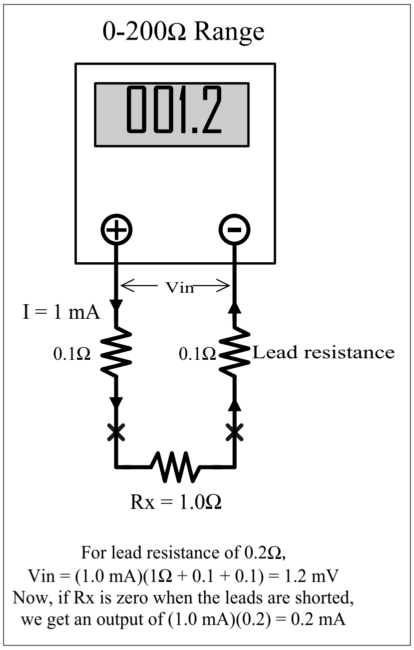


Figure 2. Realistic leads.

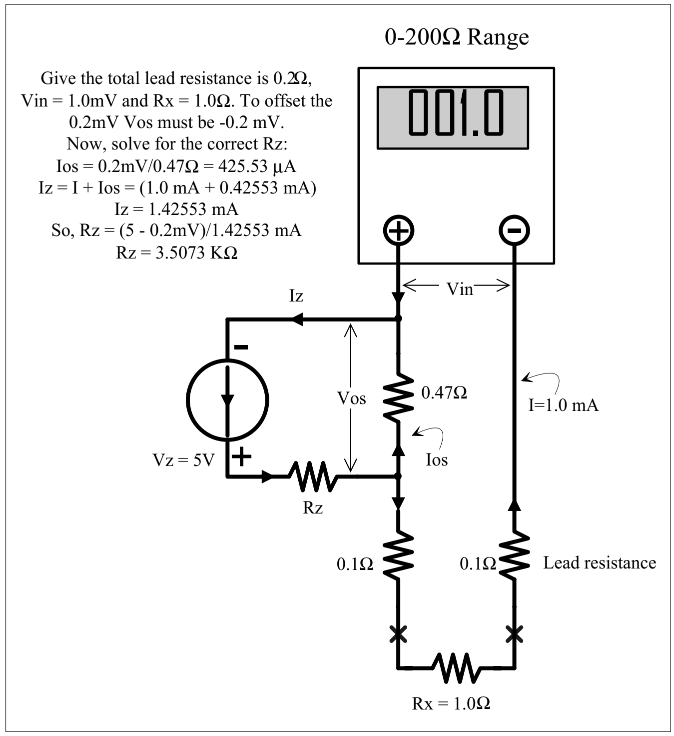


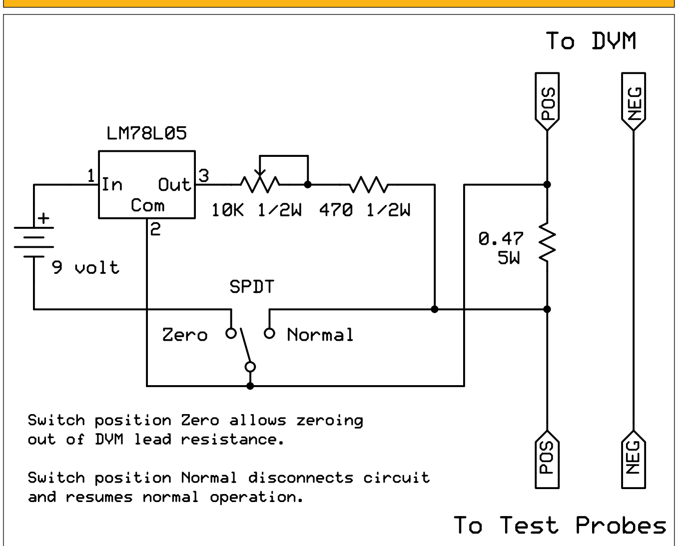
Figure 3. Current flow model of zeroing circuit in action.

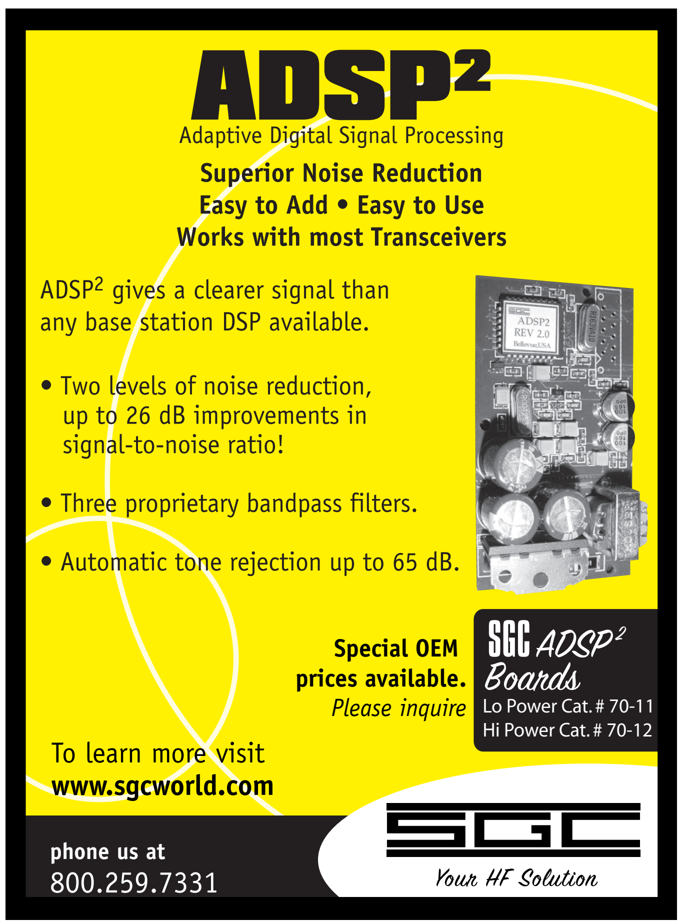
supply sends a small, adjustable current through the resistor, providing a negative bias in series with the test leads. Resistor Rz is adjusted until the display reads zero with the test leads shorted.

In the actual adapter, a 5 V regulator supplied from a 9 V battery provides the back-biasing current for the 0.47 ohm series resistor (Figure 4). An adjustable pot in series with a fixed resistor adjusts the negative bias current; the fixed resistor prevents excessive current drain on the LM78L05 regulator.

When the DVM is used on higher resistance ranges, the SPDT switch should be set to "normal," which shorts out the 0.47 ohm resistor and shuts off the bias voltage. **NV**

Figure 4. Schematic of the zeroing device.





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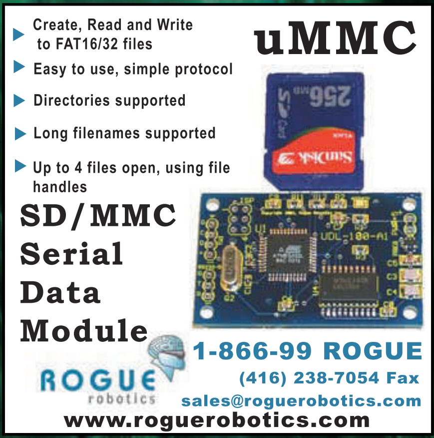

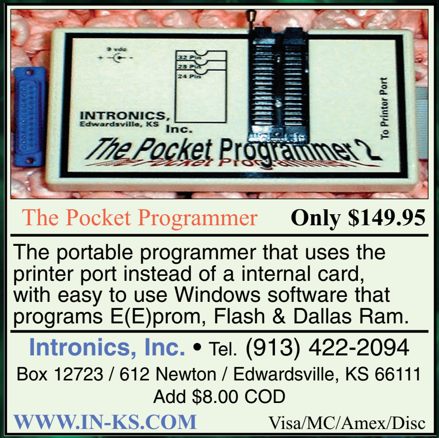

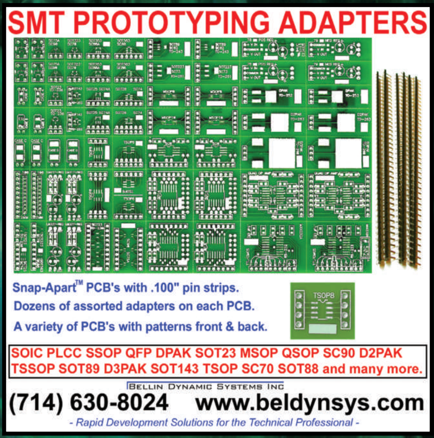

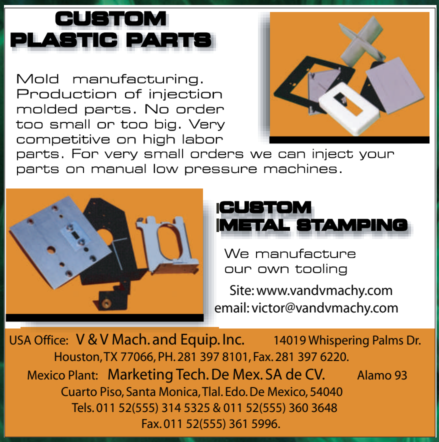

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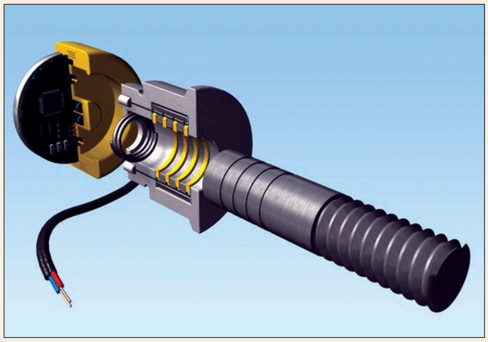
News Bytes

A New Twist of the Screw



At some point during childhood, we learned that clever adage for working with screw fasteners, "lefty loosy, righty tighty." As you are a *Nuts & Volts* reader, your parent or guardian probably lamented that bit of instruction, since it rapidly led to the mass disassembly of household appliances, VCRs, the neighbor's lawn mower, etc. Well, leave this problem to the brilliant minds at Textron Fastening Systems, who have replaced a wrench with a data cable.

The company's applications engineers are developing what they term "intelligent fastening technology" for various markets, including automotive, aerospace, and electronics. The most advanced of these applications is a tamper-proof fastening system for automotive air bag modules. This new breed of fastener actually incorporates a micro motor in the bolt shaft, responsible for tightening and loosening it in response to encrypted commands sent through a power and data connector in the bolt head. "More than 50,000 air bags are stolen in the US each year, making this the number one automotive theft problem," explains Dr. Seshu Seshasi, Executive VP of Technology at Textron.

Since I'm already unable to work on my 2003 Subaru without a code disassembler and EPROM programmer, now I suppose I'll need a supercomputer array to crack the encryption just to unscrew my license plate frame!

Security Squared

If you're like most people, you're pretty lax about maintaining computer passwords — not only are they easy to guess (child's name, favorite color, favorite hobby, etc.), but you reuse them on multiple accounts. It seems the folks at RSA Security have a good solution for locking down networks and accounts — just dangle one of these fancy SecurID Authenticator fobs from your key chain and provide the displayed number along with your password when logging in. Systems that employ RSA's Authentication Manager suite use these two pieces of information — something you know and something you have — to verify your identity.

Based on RSA Security's patented time synchronization technology, this hardware authenticator generates a simple, one-time code that changes every 60 seconds. The fobs use an internal clock and unique symmetric key for code generation, are available in 2-5 year life spans, and cost around $10.00. For more information, visit the RSA website at **www.rsasecurity.com** or one of their resellers, like NCA at **www.ncanet.com**

Putting Hot Air to Use

Even though we're done with the US presidential election campaigns, there is still plenty of hot air to go around. Fortunately, this air is pressurized in tanks and used as emergency back-up power. Yes, amazingly enough, the engineers at Active Power have come up with another novel, battery-free way of managing utility power loss for critical computing resources — TACAS (thermal and compressed air storage).

You may recall the August 2004 News Byte on this same company that described their flywheel technology for storing energy. A new addition to their CleanSource© line of UPS systems now takes a smaller version of that flywheel and combines it with pressurized air and a large thermal mass.

The scheme allows the compressed gas to expand, warm up in the thermal mass, and run a small turbine alternator to produce electric power. A single TACAS module can provide up to 15 minutes of back-up power at full load, which is an astounding 85 kW or two hours of power at 10 kW.

Active Power anticipates full production of these units by the middle of 2005. For more product and technical information, visit **www.activepower.com**

Digital Barbie

Electronic hobbyists are always on the prowl for a neat, new device to hack. As consumer electronics continue to drop in price, it seems Toys-R-Us is just as viable as Circuit City for the latest bargains. Case in point: the new Barbie digital camera

from Oregon Scientific. For a mere $35.00, you can snap 640 x 480 pixel photos to the internal 8M of memory and then download them through a USB connection. It also serves as a webcam when rigged to a PC. Sounds like the perfect addition to your next robot — assuming you wrap all the girlie pink plastic in duct tape.

Robots Go First

Four Johns Hopkins undergraduate engineering students have designed and built a remote-controlled robotic vehicle to find deadly land mines in rugged terrain and mark their location with a spray of paint.

The project resulted from a challenge to the students by Carl V. Nelson, a principal staff physicist at The Johns Hopkins University of Applied Physics Laboratory. Nelson had developed new sensors to help detect land mines, but he needed a device to carry these sensors into areas of thick vegetation, where explosives are often hidden.

To carry Nelson's sensors through rough terrain, the Johns Hopkins undergraduates designed a two-piece vehicle that rolls on tank-type treads. The front portion moves the robot, using two cordless power drill motors connected to a sealed lead-acid battery. Atop the drive segment is a color video camera, enabling a human operator to see what the robot encounters.

The drive segment is attached to a second unit that houses a simple metal detection coil obtained from an off-the-shelf treasure hunting device. The rear segment is also equipped with a small storage tank and a spray paint nozzle to mark the spot where a possible mine is located. The vehicle can spray about 40 times before the paint tank must be recharged.

The robotic vehicle was built largely with plastic and other non-metal parts to reduce cost and weight. In addition, using non-metal parts avoids triggering false positive readings from the mine detector. The two-segment design also spreads out the robot's weight, making the device less likely to set off a mine.

You may view an online video about this project on their website at **www.jhu.edu/news_info/news/audio-video/mediamines.html**

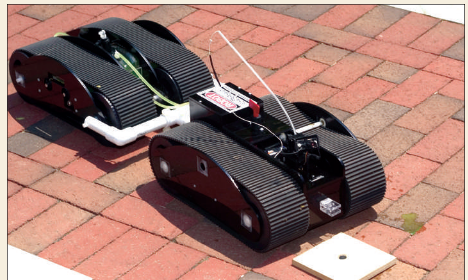
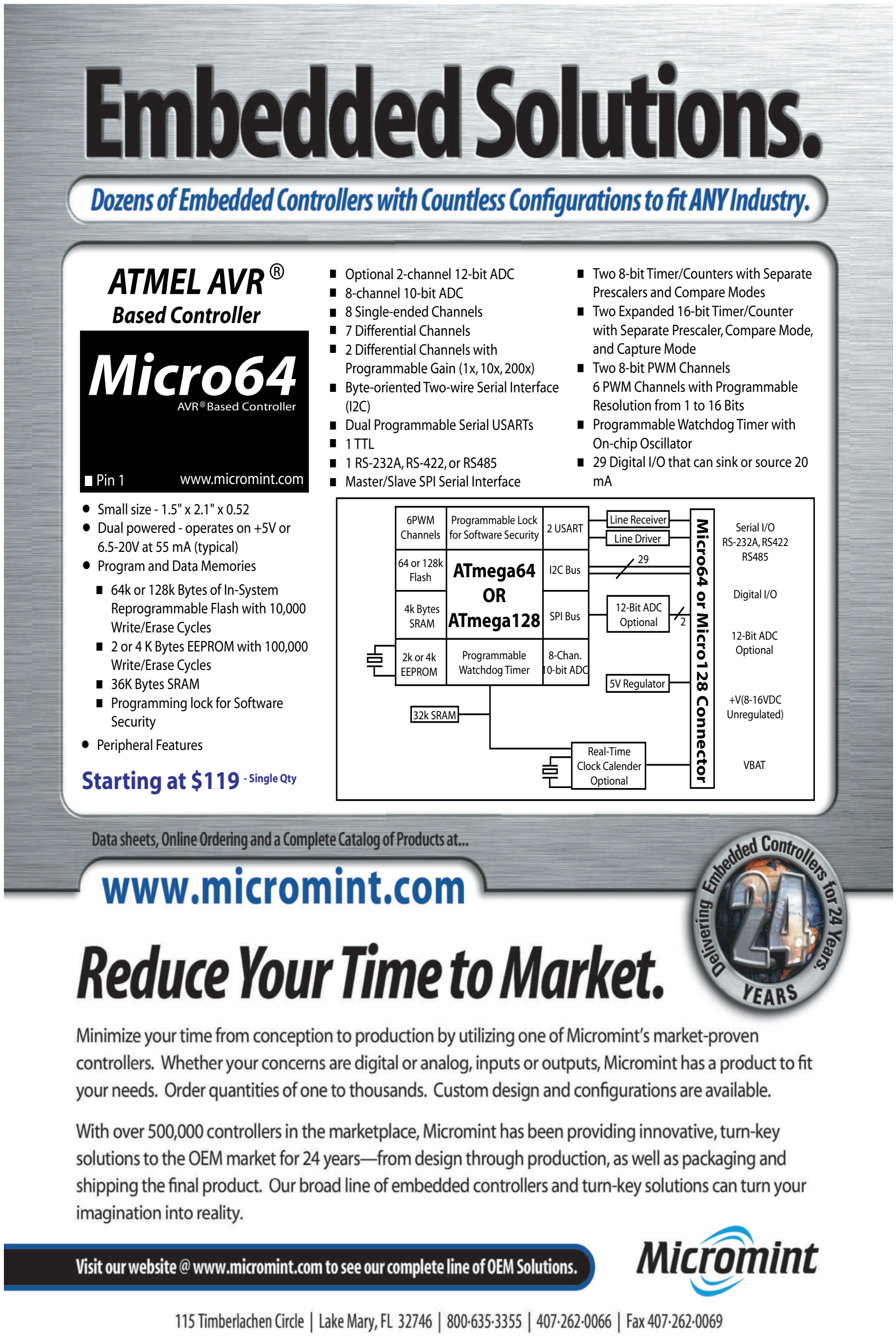


Photo courtesy of Will Kirk.



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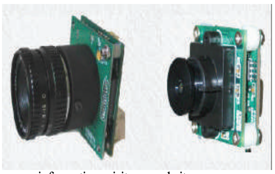

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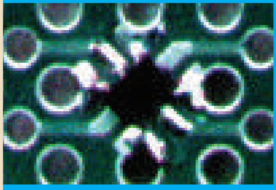

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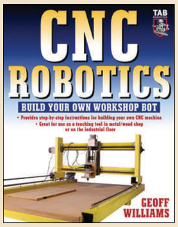

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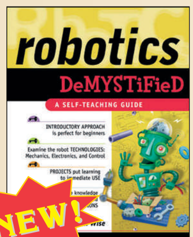

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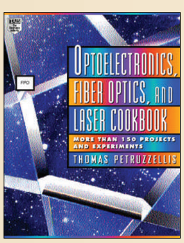

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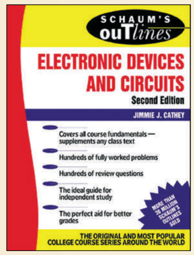

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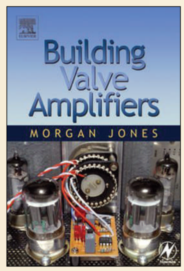

Building Valve Amplifiers is a unique, hands-on guide for anyone working with tube audio equipment — as an electronics experimenter, audiophile, or audio engineer. Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether it's audio enthusiasts tackling their first build or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by the many clear illustrations throughout. **$29.99**

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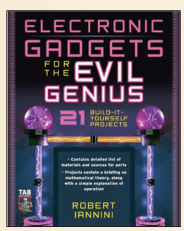

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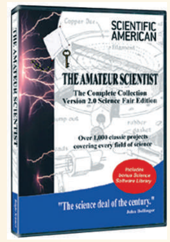

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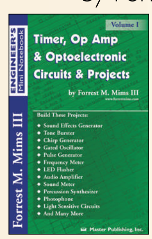

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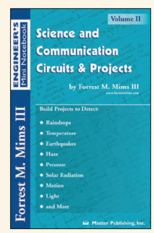

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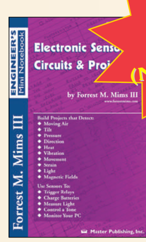

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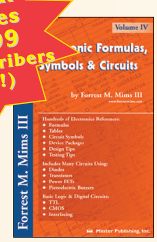

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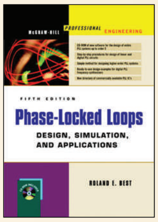

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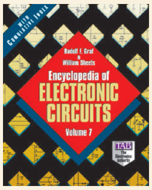

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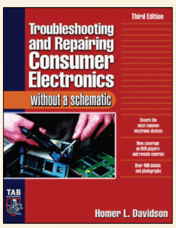

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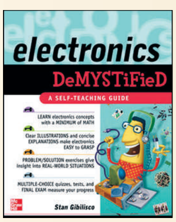

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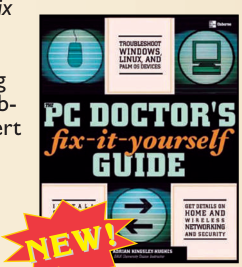

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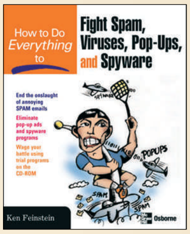

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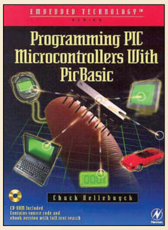

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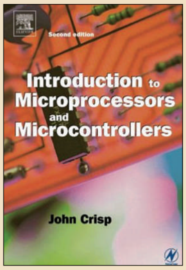

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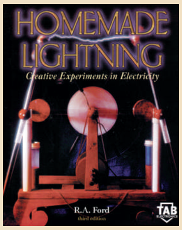

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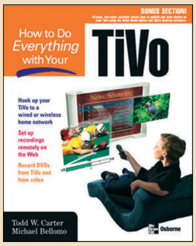

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Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp Applications

BASIC Stamp Accessories Made Easier

Not long after the BASIC Stamp started a revolution in small microcontrollers, Scott Edwards started what turned into a cottage industry: serial accessories. Thanks to the new (and free!) SX/B compiler from Parallax, you, too, can join the serial accessory club ... and do so much more.

If you were around this time last year, you may remember my absolute glee at the return of the BS1 — via programming support with the BASIC Stamp IDE that runs in Windows. I've had a great time this past year and — like our project of a year ago — I have created a few serial accessory devices using the BS1 as the host controller.

While this works and is fine for one-off experiments, it's not really practical from a cost standpoint, especially when one has a good idea that is marketable to a large group of users. Well, I've got good news about something that will top your list of stocking stuffers this holiday season: Parallax has released a free BASIC language compiler for the SX micro. Yes, that's right — free.

I can hear you now, "Crimony, have they lost their minds?" Of course not, but — as you've seen in recent months — Parallax has made getting started with the SX micro easier by reducing the cost of the SX-Key programming tool. By adding SX/B to the SX-Key software, the SX-Key becomes an even better bargain and is even easier to use.

From Problem Solver to Product

Before I get into the details, let me give you a bit of history and make sure that I manage your expectations. The SX/B compiler started out as a tool to help remove some of the drudgery of getting an assembly language program started. As such, it didn't support many of the BASIC language instructions we're all used to. However, it worked so well that the team responsible for putting it all together decided it would be worth pushing ahead, moving toward a full-fledged — albeit small — compiler. So, over the next several months, they added features that moved SX/B from a simple helper program to one that would serve the professional engineer, as well as the student or hobbyist who is attempting to make the move from low level to high level coding.

Let me start by explaining what SX/B is and isn't. SX/B is a straight, in-line compiler that converts Basic syntax to SX assembly code (very much like BS1). Being an inline compiler, no attempt to optimize program space is made — this is left to the programmer (and is not hard to do). Why not optimize? Well, optimizing compilers is very complicated (and they generally have big price tags) and the output is not really suitable to being modified by the programmer. You can do great things with an optimizing compiler, but what you really can't do (easily) is learn from it.

That's one of Parallax's primary goals for SX/B: to help people learn how to code in assembly language by seeing the assembly code output from the compiler. This is possible because every line of code is translated into a block of assembly instructions and the original BASIC code is inserted into the assembly listing as a comment. This allows you to see what's happening and — when you're so inclined — to modify the assembly code before downloading to the SX.

SX/B = PBASIC?

Well, sort of. One of the things that I think many people will find when they look at the output from the SX/B compiler is that it takes a lot of code to do what seems like a simple thing. What many will conclude, I believe, is that the BASIC Stamp does far more work under the hood than was ever imagined.

To that end, the SX/B language is somewhat PBASIC compatible; the goal was to get it fairly close to BS1 syntax with a few additions (like SHIFTOUT and SHIFTIN) and changes to simplify compiler design so that it could be used as an effective learning tool. With that in mind, complex functions like SEROUT and SERIN accept only single

output/input parameters. If, for example, you want to send or receive a string of bytes, you must do so in a loop.

Let me be very clear on this point: the SX/B compiler does not excuse the programmer from understanding the architecture and behavior of the SX micro. Don't let that worry you, though; if you've been around BASIC Stamps or other micros for any length of time, the SX will not be hard to pick up.

Follow the Line

Okay, I could fill the magazine with theoretical chat, but that's not our style, it is? Let's get right to our project — a serial line follower module that you can use with your BASIC Stamp-powered robots. Before I forget, let me give credit where it's due: the sensor design I'm presenting here isn't mine. It was designed by a very nice guy named James Vroman. I met James when he was living in Dallas, TX and was actively involved in the Dallas Personal Robotics Group (**www.dprg.org**). One of his robots, JavaBot (java as in coffee can), uses an array of sensors to follow a line. The same array is used on the Parallax line follower module in our project here.

Figure 1 shows the schematic for the line sensor array. Each element is composed of a QRB1114 reflective object sensor. Each sensor holds an IR LED and an IR phototransistor. When the LED is activated and the light is reflected from a nearby surface, the current flowing through the transistor is affected — the greater the IR reflection, the greater the current flow.

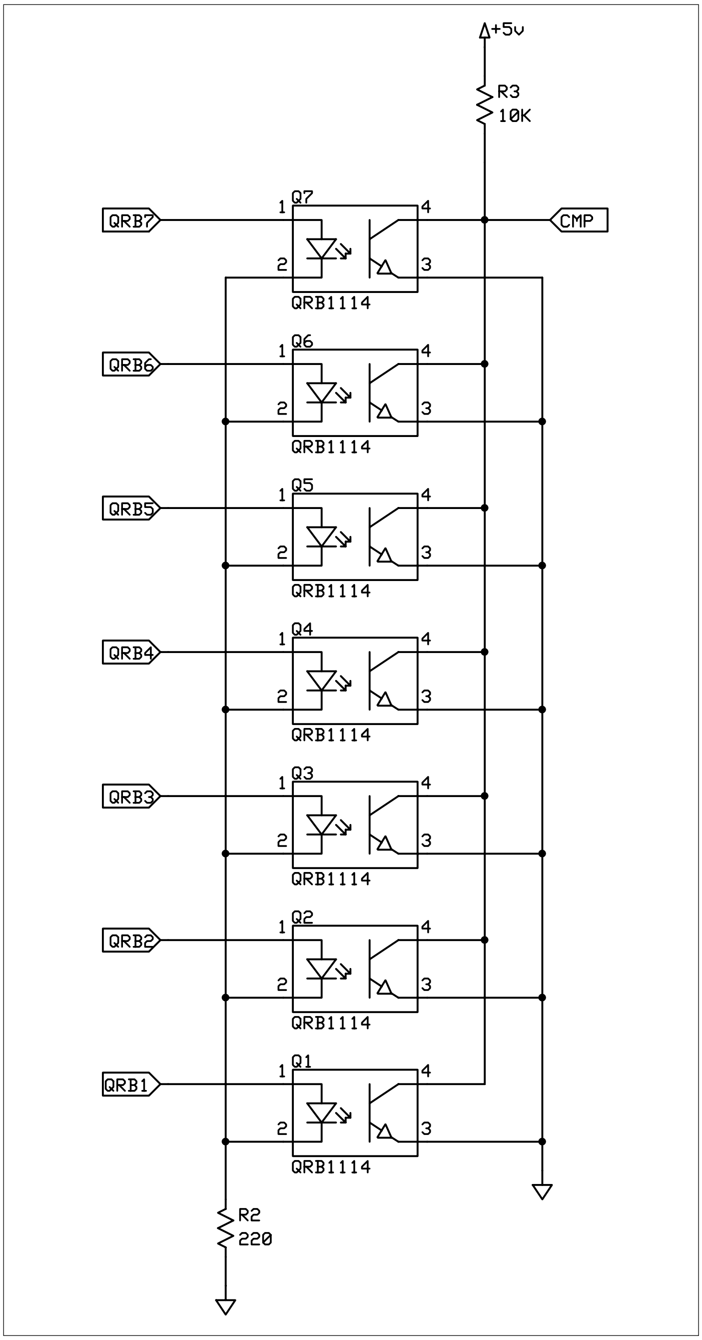
Notice that the collector of each transistor is connected to a 10K pull-up and that junction is labeled CMP. What happens is that the 10K resistor and the (activated) transistor form a voltage divider, with the output of that divider fed into a comparator circuit. By using a variable voltage into the other side of the comparator, we can set the reflection threshold for the sensor array. This allows us to "tune" the circuit for ambient light.

Okay, to activate and monitor the sensor array, we will use (of course) an SX micro; in this project, we'll use the SX28 (note that SX/B will work with the SX18, SX20, and SX28). Using the SX28 gives us plenty of I/O pins so that we can have a large sensor array. The large array lets us follow wide lines or have greater resolution and control when following thin lines.

Figure 2 shows the schematic for our SX28 controller circuit. As you can see, it's actually quite simple. Pin RA.0 is our serial I/O connection. It is pulled-up through 4.7K to make it compatible with the Parallax AppMod serial protocol, which allows for two-way communications over the same line. The pins on port RC will be configured as outputs to activate the sensor array. Finally, pins RB.1 and RB.2 are used to monitor and analyze the output of the sensor array. You see, the SX has a built-in comparator that can be enabled with code. The inputs of the comparator happen to be RB.1 and RB.2.

If you do decide to build the board (a complete schematic and board layout are part of this month's download from **www.nutsvolts.com**), make sure that you do indeed use a socket for X1. This is the socket for the ceramic resonator. If you remove the resonator, then you can run the program through the SX-Key in single step mode for debugging. You cannot debug SX code with the resonator in place. Also, by using a socket, you can select whatever frequency you choose. Just be aware that my simple design borrows power from an external source (i.e., the BOE-Bot) and the faster the SX runs, the more current it will consume.

Figure 1. QRB1114 sensor array schematic.



The Code That Follows the Line

Before we actually jump into the code, let's talk about requirements. First, we want the module to be compatible with the Parallax AppMod serial protocol. What this means is an open baud mode, bidirectional serial link. If you're a little fuzzy on the concept of "open" baud modes, let me try to clear things up. When using an open mode, the BASIC Stamp will drive the serial output pin one way or the other (depending on mode — true or inverted) and rely on a pull-up or pull-down to take care of the other pin state. In our case, we're going to use true mode, which means the serial line rests at a high state and an active bit is a low. What we have to do, then, is pull the line to Vdd through a resistor. When a "1" bit is transmitted, the line will be pulled low by the SX or the BASIC Stamp. For a "0" bit, the serial output pin is made Hi-Z (input state) and the pull-up takes care of the rest.

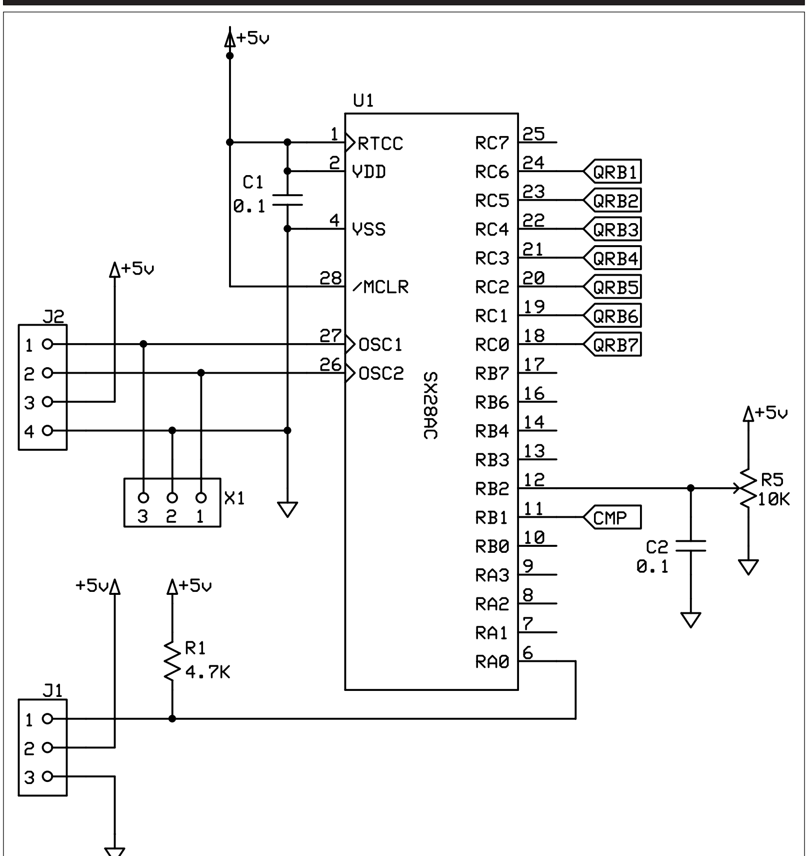
Why go through all this? Well, what this does is let us connect a bunch of devices to the same line and — if more that one goes active at the same time — there is no danger of a short. If, for example, the BASIC Stamp and the SX both pull the line low at the same time, there will be a data collision for sure, but no short circuit, since they are at the same state. However, if one pulled the line low while the other was trying to drive the line high ... we could end up with blue smoke.

Now that the protocol is settled, let's talk features. How about querying the device for a firmware number? I think that's a good idea, especially if we intend to create a product for sale; we can allow the user to identify the firmware version of that device. Since we're building a line follower, all that's left is to return the line bits. Just to simplify things for the BASIC Stamp, let's create two line functions: one that returns the bits when the line is white on a black field and another that returns the bits when the line is black on a white field. Both functions will return a "1" when the sensor element has detected the line.

Time to jump in! Within the SX/B program, there must exist a directive called **PROGRAM** that tells the code where to begin after the start-up code (I/O and variable initialization) is executed. If an ISR (Interrupt Service Routine) is declared, the directive must come after that. In our case, the directive is **PROGRAM Start**, so the code will begin its execution at the label **Start**.

You're probably wondering why the subroutines are placed ahead of the main code. This has to do with the SX architecture. The entry point of a subroutine must be in the first half (256 words) of the code page where it lives. The SX28 has four code pages of 512 words (2K total). This program is small and everything fits into page 0. For larger programs, we can create a "jump table" and move subroutine code to another page — but that's beyond the scope of this article. The SX/B help file gives plenty of good examples showing how to handle larger programs.

Figure 2. SX28 line follower controller schematic.



Back to **Start**. The first instruction you'll see is **ADDRESS $100**. The **ADDRESS** directive forces the code to be placed at a certain location. By forcing the start code to this address, the assembler will complain if our subroutines run too long. This wasn't the case here, but it is still a good idea to use if you're going to put your subroutines on page 0.

The next few lines set up the I/O structure. On the SX28, we have three ports (RA, RB, and RC) for a total of 20 I/O pins (RA has only four pins). On ports A and B, we have a bunch of unused pins and it's not a good idea to leave these floating. What we can do, then, is activate the weak pull-ups on the unused pins to pull them into a known state. What you have probably noticed is that a 0 in the respective bit activates the pull-up. When using the TRIS registers (equivalent to the BASIC Stamp DIRS), a 0 causes the respective pin to be an output — this is just the opposite of how we program the BASIC Stamp and we must remain mindful of this fact when programming in SX/B.

In short, our setup section sets all unused pin inputs and enables the pull-ups on those pins. The reason that RB.0 is made an output when it

is not connected to anything is that it will hold the state of the comparator, so the comparator result will make it high or low and allow us to read that bit as part of our line scan.

With the I/O pins initialized, it's time to start — start waiting, that is. This device is a serial slave and speaks only when spoken to. The front end of the code (that begins at **Main**) waits for the proper message header. In our case, that header will be "!LF" (for line follower). Here's the code that waits for the message header:

```
Main:
  GOSUB RX_Byte, @char
  IF char <> "!" THEN Main
  GOSUB RX_Byte, @char
  IF char <> "L" THEN Main
  GOSUB RX_Byte, @char
  IF char <> "F" THEN Main
```

The "!" character is a legacy thing from the AppMod serial protocol. In some AppMods, the "!" is used to detect and set the baud rate. We can't do that (auto-baud detect) without resorting to assembly language, so we've fixed our baud rate to 9600. This is about as fast as we can go when using a 4 MHz clock.

As I stated earlier, many of the functions in SX/B work differently than their BASIC Stamp counterparts. **SERIN**, for example, will wait for a byte — one byte — and we have to do our own filtering. Also remember that, each time we have **SERIN** in our program, it gets translated into a set of assembly instructions. If we have a bunch of **SERINs**, we could quickly chew up our programming space. To save space, we can put **SERIN** into a subroutine and even give it the ability to work with parameters. Here's that routine:

```
RX_Byte:
  rtnAddr = __PARAM1
  SERIN Sio, Baud, temp1
  PUT rtnAddr, temp1
  RETURN
```

On entering the subroutine, we make a copy of an internal SX/B variable called __PARAM1. This variable holds the first parameter sent to the subroutine. Now, go back and look at the code at **Main**. Notice how we call the subroutine with a variable and the "@" character is in front of that variable. What the "@" character does is tell the compiler to send the address of the variable instead of its value. This is very powerful because it lets us create a subroutine that can affect any variable we send to it using this technique.

Back in our **RX_Byte** subroutine, we then use **SERIN** to receive the byte and return it to the variable that was passed by using the **PUT** function. **PUT** takes a location

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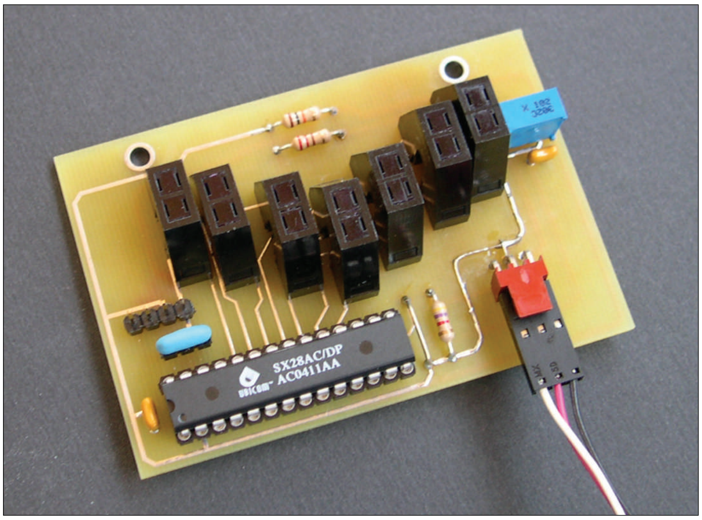
Figure 3. Line follower PCB (board by ExpressPCB).

and value as arguments; in this case, we are putting the variable received by **SERIN** into the address that was passed to the subroutine.

Once we've received a byte, we compare it to the list of valid characters in our header string. If there is ever a mismatch, the code is forced back to the beginning. Once we have received "!," "S," and "L" — in that order — we will wait for one more byte that will be the command to process.

For our line follower, there are three valid command bytes: "V" (return version), "B" (return black line bits), and "W" (return white line bits). Let's start with "V." In fact, let's show how to get the BASIC Stamp to request and wait for the version code from our line follower:

```
SEROUT Sio, Baud, ["!LFV"]
SERIN Sio, Baud, [STR version\3]
```

Pretty simple, right? It is — but there's something we need to be aware of when designing serial accessories for the BASIC Stamp. Even though the Stamp does a **SERIN** right after the **SEROUT**, it is still much slower than the SX. What this means is that the SX has to allow time for the BASIC Stamp to get ready before sending any information back. You'll see that in just a second.

```
Check_V:
  IF char <> "V" THEN Check_B
  GOSUB Delay, 250, 4
  idx = 0

Next_Char:
  READ Rev_Code + idx, char
  INC idx
  IF char = 0 THEN Main
  GOSUB TX_Byte, char
  GOTO Next_Char
```

When we do receive a "V" command code, the **IF-THEN** line will fail and the program will drop through to a call to another subroutine, named **Delay**. This is another case where program space is conserved by placing high-level (lots of assembly code) functions into subroutines so that the high-level functions are compiled in one place. Let's have a look at the **Delay** subroutine:

```
Delay:
  temp1 = __PARAM1
  temp2 = __PARAM2
  PAUSEUS temp1 * temp2
  RETURN
```

This subroutine is expecting two parameters: a delay value and a multiplier. You may be wondering why we have to save __PARAM1 and __PARAM2. The reason is that these variables will be used when the **PAUSEUS** (pause in microseconds) subroutine gets compiled; if we didn't save the parameters that are passed, they would ultimately be clobbered.

Since we don't need particularly long delays in this program and there is a time when very short delays are needed, we're using **PAUSEUS**. We're also using a syntax variation that lets the ultimate delay be the product of the two values passed to it. With this syntax, we could create delays up to 65 milliseconds. By passing 250 and 4 to the **Delay** subroutine, we create a delay of one millisecond;

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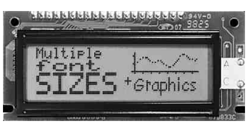

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this is plenty of time for the BASIC Stamp to load its **SERIN** routine and be ready for what we send back to it.

Now that the BASIC Stamp is ready, we can transmit the three character version string. The string itself is stored in a **DATA** table, very much like we would do with a BASIC Stamp. The difference between the SX and the BASIC Stamp is that SX tables are read-only; we cannot rewrite them at run time.

The transmission code is pretty easy; it grabs a character from the string (table) and — if it's not zero — it sends it to the BASIC Stamp. Here's the transmit subroutine code:

```
TX_Byte:
  temp1 = __PARAM1
  SEROUT Sio, Baud, temp1
  RETURN
```

By now, the structure should be fairly obvious: We make a copy of the parameter (variable) that gets passed and then send it out. In this case, though, we don't use "@" so what we end up passing is the value of the variable.

The last major step is reading the line sensor array. If the command byte is "B" or "W" we will read the sensor array with this code:

```
Get_Line:
  rtnAddr = __PARAM1                                    ' save
return address
  CMP_B = 0                                             '
enable comparator
  temp1 = %00000000
  FOR idx = 0 TO 6
    Sensor = 1 << idx
    \ MOV __PARAM1, #250
    \ DJNZ __PARAM1, $
    temp1 = temp1 << 1
    temp1.0 = CmpOut
  NEXT idx
  Sensor = %00000000
  PUT rtnAddr, temp1
  CMP_B = $FF
  RETURN
```

As with the RX_Byte routine, we're going to pass an address parameter to Get_Line. When we're done, that address (hence its variable) will hold the current line sensor value. On entering the routine, we activate the SX comparator by clearing bits 7 and 6 of CMP_B (comparator setup register). By doing this, the comparator is enabled and its result output is routed to RB.0 (aliased as CmpOut).

The bulk of this routine is a loop that activates a single sensor in the array. After the sensor is activated, there is a short delay to allow things to settle. One of the (many) neat things about the SX/B compiler is that we can insert assembly code when we want to. In this case, we'll pop in two lines that will ultimately result in a 250 microsecond delay. Yes, we could have used our **Delay** subroutine, but why not stretch a little bit and have some fun?

After the delay, we will rotate our temporary line bits

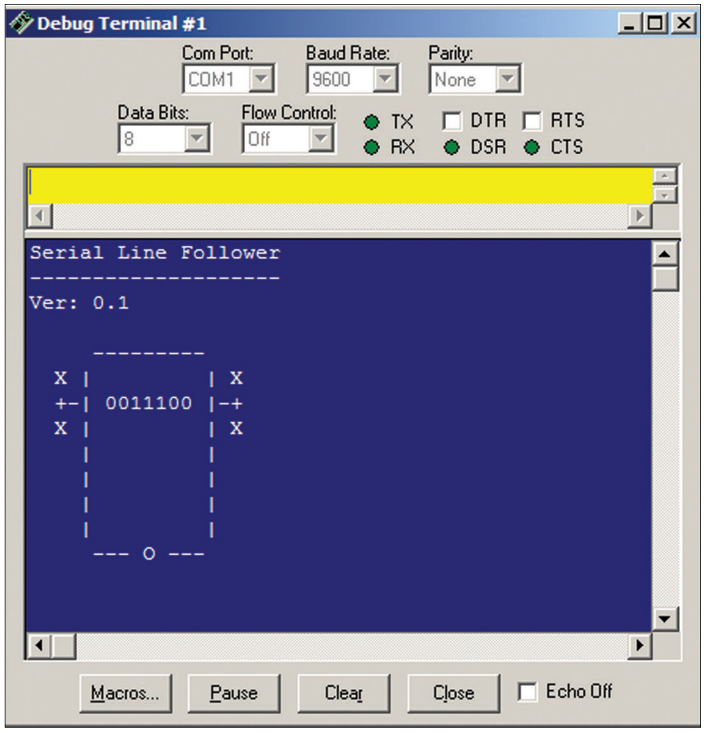

Figure 4. Output from BASIC Stamp test program.

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variable and then place the comparator output into bit zero of it. By going through this loop seven times, we end up with a byte that holds the value of the line sensor array. Keep in mind that the value is going to be affected by the setting of the pot connect to RB.2. The pot is used to set the sensitivity of the sensor elements, so we're able to tune the circuit for ambient lighting.

When the loop is complete, we finish by making sure that all the sensors are off, moving the scan result to the passed variable, then shutting down the comparator to conserve as much power as possible.

The design of the sensor array and the comparator inputs will return a "1" bit when the sensor is over a highly reflective surface. Well, what happens when we have a black line on a white surface? It's actually pretty easy to deal with. Let's have a look:

```
Check_B:
  IF char <> "B" THEN Check_W
  GOSUB Delay, 250, 4
  GOSUB Get_Line, @lnBits
  lnBits = lnBits XOR %01111111
  GOSUB TX_Byte, lnBits
  GOTO Main
```

After retrieving the line sensor value, we can invert the bits using XOR, then send it off to the BASIC Stamp. Once the line value has been transmitted, the code returns to the top of the program and waits for another command sequence.

For those who want to build this serial line follower project, I've included the schematic and PCB layout in ExpressPCB (**www.expresspcb.com**) format. Please understand that using these files is done at your own risk. I'm certainly no PCB designer — heck, I'm barely a programmer. Please check everything carefully before you make an order. I actually found an error in my first layout that I corrected with a bit of PCB surgery. That error has been removed from the project files that you can download.

Figure 3 shows my prototype board, ready to mount on the bottom a BOE-Bot. What, no BOE-Bot? Well, RadioShack carries them now, so a robot may be available in your neighborhood as you read this. Figure 4 shows the output of the BASIC Stamp test program that can be used to calibrate the sensor pot.

There's More ... A Lot More

Wow, I'm out of breath — and out of space. Let me assure you that SX/B is a lot of fun to play with and, with a bit of patience and study, you'll be as confident at it as you are with the BASIC Stamp. You're probably wondering how you get the SX/B compiler. The answer is as simple as downloading the SX-Key software from Parallax; SX/B is built right in. Of course, you'll need an SX-Key to program the SX chips and some sort of programming board. Parallax has a small development board called the SX Tech Board and — if you're feeling really industrious — you could even build your own.

Parallax has a couple great books on the SX and more are coming. You can download Al Williams' book, *Exploring the SX Microcontroller with Assembly and BASIC Programming*; Günther Daubach's book, *Programming the SX Microcontroller — A Complete Guide* is available in a bound volume. There is a version of the SX-Key starter kit that includes both of these books, the SX-Key programming tool, and the SX Tech Board — it's a great way to get started with the SX. As for the Internet, James Newton's SX List (**www.sxlist.com**) is full of useful information and tips on programming the SX micro. Check it out.

As I close, please accept my sincere wishes for a happy and peaceful holiday season. Until next year (which is just a month away!), Happy Stamping. **NV**

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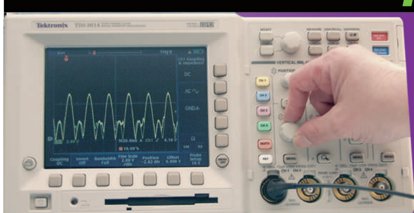

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In The Trenches

How to Make Projects That Work

There is probably nothing more frustrating, annoying, and embarrassing than spending a week on a "simple" project that doesn't work, only to have someone else do it in an afternoon and with a handful of junk-box parts. What makes some people better at getting things to work properly? In this special all-projects issue, we'll look at ways to make you more successful in making projects that work.

Basic Practical Experience

Probably the single most important aspect behind making an idea work is practical experience. The more you have, the easier it is to succeed. This experience starts at the most basic level. Can you make reliable solder joints? Note that this is different from making "good" solder joints. "Good" solder joints are those that are both reliable and meet some reasonable standard of quality. For a project, all that is required is that the joints be reliable. Reliable joints will become "good" solder joints with more experience.

Soldering is, indeed, a skill that takes some practice to learn (but not all that much). I would hate to estimate the number of times I've seen something fail because of bad soldering techniques. I will say that a huge number of newly-degreed engineers can't solder well. Often, technicians will end up soldering for them. This delays the learning curve. Then, when they are faced with the need to solder without the aid of a technician, bad results happen. Every electrical engineer should be able to make reliable solder joints. It's interesting that most hobbyists, in contrast, generally have good experience in soldering.

Other kinds of basic experience are also required. Part identification and orientation is fundamental. I can't count the number of times I've seen ICs inserted backward — not from carelessness, but from ignorance. Quite simply, this is a case of not knowing which end is up.

Knowing the resistor color code is also important. It may help to note that it goes from black to white with the color spectrum in the middle (black, brown, red, orange, yellow, green, blue, violet, gray, white). Being able to tell the difference between different types of capacitors is also important. A ceramic capacitor acts very differently from mica or polyester types.

Understanding voltage and polarity ratings for capacitors, diodes, and other semiconductors is critical in making something work.

If this sounds too fundamental, that's good. That means that you've got the basics down. If the basics aren't there, it's going to be very hard to get projects to work. I know this from my own past experience.

I first got interested in electronics in my early teens by picking up a *Popular Electronics Magazine*. From there, I followed a randomly directed and very informal path into engineering. I collected junk radios and TVs, tried to fix a few (with poor results), and disassembled the rest.

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(This provided practical soldering/de-soldering and part identification experience.) There were, however, two assets that I now recognize were very important. The first was that I read everything I could about electronics — not just about one or two areas. I had a voracious curiosity. The second asset was an "electronics lab." This was just a kit of parts that could be connected and reconnected to make various radios, etc. (Equivalent kits are still available.)

The kit allowed me to be successful in building things. I quickly built a shortwave radio as an early "project." I immediately learned that a good antenna and groundwere important in trying to hear stations from the other side of the world. (I remember picking up Radio Lebanon.) That lead to experimentation with antennas and grounds. With a working kit radio, I could create strange and wonderful antennas and compare their performance. While my antenna attempts were naive and crude, they provided a practical groundwork in the important area of test and measurement. (Even though I was not aware of it.)

When you are just starting something new, it's important to be successful in order to maintain interest. Kits and "labs" are extremely useful in this regard. It's also very important to have something that works before you start experimenting with it. I know from my own experience that virtually all of my early "grand ideas" failed. If I did not have the "lab" where I could follow instructions and make something that actually worked, I'm pretty sure that I would have abandoned electronics. More simply, success breeds success. In the early stages of learning, it's important to lean on other people's knowledge.

Reaching Too Far

It's so easy to think you can make something that's really far beyond your capabilities. In fact, for many engineers, it usually takes a very significant effort and a brutally honest self-evaluation to think the opposite. The cliche, "a little knowledge is a dangerous thing," is very appropriate. Generally, overreaching is based on the lack of practical experience and theoretical knowledge.

For example, when I first read about a Darlington transistor pair that acted like a super transistor, I had to try to "improve" it. If a second transistor made a 10-fold improvement in amplification, then five or six transistors should make a 100,000-fold to 1,000,000-fold increase. This "project" failed because I didn't understand noise, stability, and a host of other concepts.

I should point out that overreaching is a major cause of failure in any engineering or business project — professional or otherwise. Whether it's the government that's pushing autonomous vehicles or the marketing manager who accepts impossible specifications or the digital engineer who thinks he can easily create a multi-GHz spread spectrum receiver, overreaching causes failure.

Note that overreaching is often a very good learning tool. You don't learn anything new by doing the same thing over and over, but success comes from being able to realistically evaluate your own capabilities. Naturally, there is a trade-off here. The farther you reach, the greater the reward is for success — versus a greater risk of failure. It's fairly rare for someone to be able to consistently know where the optimal point is.

Floundering

Floundering is usually the result of overreaching. When it happens to me, I feel like a fly beating my brains out against a window. (Yes, it still happens to me.) The important thing is to realize the situation early. Unfortunately, it seems to be human nature to deny the obvious. I have seen smart engineers work for months on a project without any headway, unwilling and unable to see that there is a problem.

There are two basic solutions to floundering (failure is NOT an option) — learn new information or choose a new approach. Remember, you are floundering for a reason, but you don't know what that reason is. So, instead of spending more time and

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effort beating your brains out, stop and use your brain. Take a step back and ask yourself exactly what the problem is. Be specific.

For example, I was recently working on a 10 MHz amplifier. I wanted a cheap and easy design, so I used a digital CMOS inverter in the analog mode. I had done this before with good results. However, this time I needed a much higher gain. It couldn't be done with a single stage and — when I added multiple stages — the circuit oscillated. Try as I might, I couldn't eliminate the oscillations from multiple stages. Finally, I decided to analyze the situation rather than overcome it.

I systematically tried different input circuits, feedback resistors, output loads, and a number of other parameters. I learned several things. The first was that a capacitor-coupled input was bad (but my design required it). The second was that the chip was sensitive to VCC noise. I determined that the procedure that I chose simply wouldn't work. The CMOS chips were not designed for analog operation and the fairly complex analog circuit I needed was simply beyond their capabilities.

So, I abandoned that design approach and went with a three-stage discrete transistor design that worked acceptably well. Yes, the transistor approach was more complicated and needed more parts, but it worked. After spending several days on a bad design, I had the new design functioning in an afternoon.

Multiple Choices and Targets

There are almost always a number of ways to approach any project. Digital or analog? Embedded computer or discrete logic? Software or hardware? The choice you make is usually the one you are most comfortable with (human nature again). This is not necessarily the best. Obviously, if you have experience in hardware, software, analog and digital design, you will have more comfortable options than someone with just analog experience.

Each of these areas is like a tool in your tool box. You may be a whiz with a hammer, but a hammer is not a good tool to cut a board with. If you want to be successful with a project, then choose a project that complements your strengths. As in many other endeavors, do what you do best.

This brings us to defining the purpose of the project. Are you trying to learn something new, demonstrate some principle, have fun, or create a product you can sell? The purpose will have a great bearing on your design approach and how easily success is defined. If you are just trying to learn something, then success is very simple. You can learn that you can't filter AC with an electrolytic capacitor quite quickly. On the other hand, a commercial product's success can really only be determined after it has been in the marketplace for some time.

Some Specifics

Let's look at some specific points that can help get your projects working. I think the most important point one is the KISS principle — Keep It Simple, Stupid. A simple and direct approach to a project is nearly always going to be more successful than a complicated one. True, there are occasions where simple and direct don't work, but — given a choice between a simple and a complicated design — the simple design is usually much better.

An important part of KISS is the "Keep" part. It's common to start out with a simple design and then add a few parts to perform one function. Then, a few more parts are added to do something else, and so on. Pretty soon, the project consists of a hoard of small circuits that interact in a very complicated manner. It's not simple anymore.

At some point (preferably at the start), all of the project specifications should be listed. It's from these specifications that the design approach should be chosen. It's much easier to make a working project from a list of specifications than to keep changing and adding parts to it. Rube Goldberg may have created many amusing designs, but they were all very difficult to implement.

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However, don't confuse this with the step-wise design approach. With this procedure, you concentrate on getting one part of the project to work at a time. This approach works for both software and hardware and can be very effective. Let's look at a couple of examples.

For software, the very first part I work on is the output. I do this because it gives me a window into the software. Once I get the output to work properly, I can use it to show me various variables for debugging. For example, is my loop-counter incrementing as I expected? Is the analog-to-digital converter working properly? It's much easier to find a problem if you can look at parts of it.

For hardware, I use a similar technique, but for different reasons. I usually start with the most important or sensitive circuit, if possible. In that way, I can see how the rest of the circuits affect it as I add them, one by one. Circuit interactions are fairly common and they are often difficult to predict. By using a step-wise approach, I learn about the interactions one at a time, rather than trying to separate them from each other en masse.

Documentation Details

A great portion of engineering is just common sense with attention to detail. It is impossible to over-emphasize how important the details are. (I'm sure everyone can think of a disaster or near disaster that resulted from an overlooked detail.) Examining the details before you start a project and anticipating the problems is an excellent way to succeed.

Many hobbyists don't think they need to worry about timing diagrams, schematics, or other documentation. After all, it's "just" a project. The truth of the matter is simple; if you want that project to work, then this documentation is vital. I can't say how many times I've breadboarded a circuit that should have worked, but didn't. It's only after I have the schematic that I can see that I've wired the breadboard wrong. The same is true for digital circuits. I think I know the circuit, but it's after I make a timing diagram that I see the race condition or the faulty logic.

The argument that, "it's just a simple circuit, so I don't need a schematic," is false. If it's such a simple circuit, then a schematic (or timing diagram) should be quick to make. I always make schematics now. I have found that they always seem to save me time in the long run. Perhaps more importantly, if I want to use or modify the circuit years later, I have extremely useful documentation. (By the way, my most recent

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schematic consists if a single 74S86 IC, three capacitors, two resistors, and a three-pin module.)

Parts Details

Attention to parts details is also critical in order for projects to work. Here's a true story: A client was having problems with a product. I traced the problem to lots of noise on the +15 volt supply. "How could that be?" they asked. "We're using a standard 7815 three-pin regulator. It's supposed to be very quiet." It is true that the three-pin regulators are very quiet, but that wasn't the problem. The problem was that they were using a 12 volt transformer to make the 15 volt supply. The 12 volt RMS transformer provided a peak voltage of 17.0 volts, but the 7815 needs 17.7 volts input, minimum. It fails to regulate with less voltage; therefore, the voltage regulator couldn't do its job because the circuit details weren't correct.

Many hobbyists and engineers (who should know better) choose parts for their function without too much regard for their peripheral specifications. Clearly, this is not good. You should read the full data sheet and understand it before using any part. I know a lot of readers will think that it's too much work. Truthfully, it's not work if you are serious about your hobby (or job). Nowadays, with all the manufacturers' websites, it's easier than ever to get the data sheets for your parts.

If you have trouble understanding the data sheet, you should get the data book. Most manufacturers will send you a CD copy or you can down-load one (if you have a fast web connection). The data book should have definitions and explanations for the specifications on the data sheet. Additionally, the book will often have application notes that show how to hook up the part and what to expect from it. Many times, you can use these circuits to form a core for your project. Reading data sheets and data book application information is very educational. This is especially true for parts that are new to you.

If you are building someone else's design, use the parts they specify, unless you are absolutely sure you know that a different part will work. Different 74xx families are not directly interchangeable. These families have wildly different speeds, current needs, and operating voltages. Always remember that RF circuits and switching power supplies require precision coils. For some reason that I haven't figured out, inductor values seem to be immaterial to many people. Just grabbing a random choke from the junk-box will not work. Always pay close attention to voltage, current, and power ratings.

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It's silly to risk fire or personal injury just to cut corners.

Think! Think! Think!

Your best bet to make a project that works is to use that tool between your ears from start to finish. Make a plan and follow it through. If you have a problem, stop and think. It's very common to assume you know what the problem is when it isn't that at all. (I know that from experience.) Take notes on the problem. This will help organize your thoughts and help keep you from repeating previous efforts.

Anticipate problems and address them from the beginning. They will NEVER disappear on their own. Don't think that oscillation or noise in a breadboard design will go away when you use a printed circuit board. First, find the cause and eliminate it. It is true that a good PC design can be very quiet and reduce the likelihood of oscillations. It is also true that, if the breadboard oscillates, you have probably overlooked something.

Organizing your work area will help keep your thoughts focused. If you can't find your multimeter in the mess, you can't determine if the voltage is correct. If it takes 10 minutes to find it, you may forget what you wanted it for. Know that your instruments are not perfect. They may lie to you. In particular, high impedance measures are not always what they seem.

Finally, we come back to experience. There is no substitute for it. There is no easy way get experience. You simply have to practice. Like the piano or any other skill, the more you work at it, the better you will become. Making projects that work is a skill that comes from making projects that don't work. You can't expect to play the piano the first time you sit down. Playing the piano takes a lot of work and a lot of wrong notes. Practical engineering is no exception. Clearly, understanding the principles and theories is very important in designing a project, but making it work means that you have to get your hands dirty.

Conclusion

The biggest factor in making projects that work is practical experience. This can only be obtained by actually making projects. Newcomers should concentrate on the basics and consider getting an "electronics lab" or building kits. Those with some experience can improve their success rate by learning more and targeting their projects to their strengths. Like any other skill, making projects that work requires a lot of practice. **NV**

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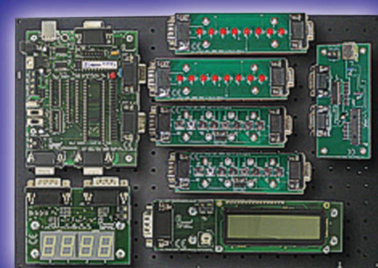

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Back to the Bands

A weekend project to return to amateur radio with kits — it doesn't get any better than this.

Commercial electronic kits are still one of the best ways to enjoy building electronic equipment if you are not a formally educated engineer or technician. They are inexpensive, easy to build, and also very satisfying — since they actually work, unlike many home-designed and built projects.

Just recently, I decided to get active again in amateur radio. I have been a licensed ham for most of my natural life, but — over the years — my ham activity level has ranged from several hours a day to none. I thought that building some kits would be a great way to re-enter this hobby. I wanted to get my CW code skill back. For those of you who have been out of ham radio for a while or have no ham experience other than two-meter repeater work, this is a great way to get a totally different perspective on ham radio.

I had the pleasure of working for the premier electronic kit company — Heathkit — during its heyday: great fun. I was very active in amateur radio then and enjoyed building and using most of the Heathkit ham products. One of the most fascinating products was a QRP (low power) transceiver called the HW-8. It had a good receiver and a low power transmitter for the HF ham bands: 80–20 meters.

It worked great and — like many other hams — I enjoyed the challenge of making many contacts without the high power (100 watts plus) most other hams used. For my return to ham radio, I wanted to experience that QRP feeling again. I began searching for a kit.

There are not too many ham kit companies around today, but one of them had just what I wanted. Ramsey Electronics (**www.ramseykits.com**) sells a series of very low cost receiver and transmitter kits for QRP operation. Models are available for the 80, 40, 30, and 20 meter bands. I had never used the 30 meter band (10 MHz) before, so I selected the HR30 receiver kit and the QRP30 transmitter. In this article, I want to report on my experience of building and using the receiver; I will cover the transmitter in the February issue.

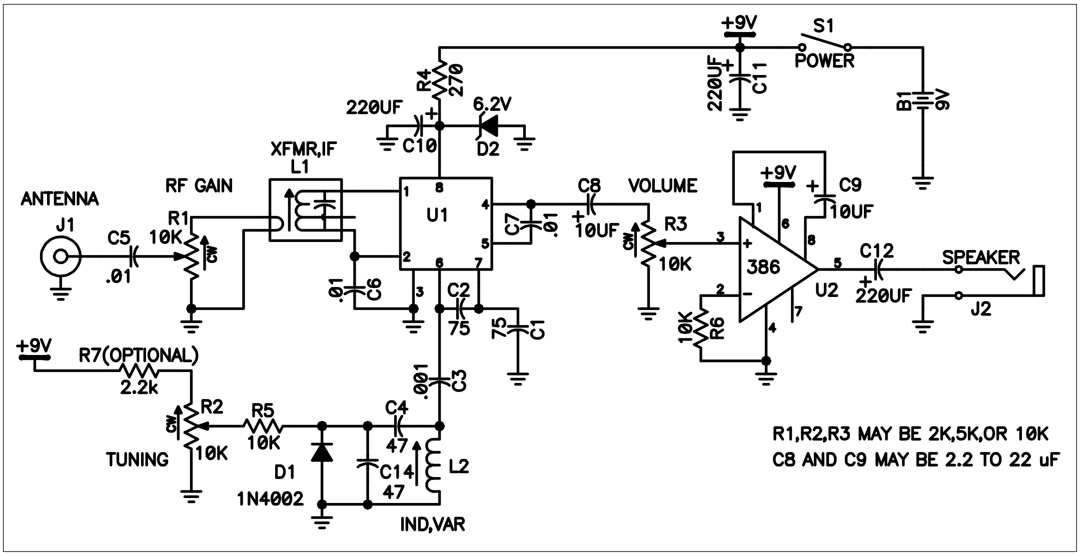
The Receiver Circuit

Figure 1 shows the HR30 schematic diagram. It is a direct conversion (DC) receiver, an architecture that some refer to as a zero IF (ZIF) receiver. It is a superheterodyne type in that it uses a mixer to convert the received RF signal down to a lower intermediate frequency (IF). The mixer multiplies the input signal, fRF, by an internal local oscillator (LO) signal, fLO, and produces the sum and difference frequencies of the two inputs: (fRF+fLO) and (fRF-fLO).

The IF is usually the difference between the input frequency and the LO signal; it typically falls in the 1 to 20 MHz range. IFs of 50 kHz and 455 kHz are also common. The sum of the two inputs is filtered out. The receiver selectivity is then obtained at the IF using a crystal or ceramic filter. In a ZIF radio, the local oscillator is set to the signal frequency, so — when you subtract one from the other — the result is zero.

You are probably wondering how you hear anything with zero IF. What you do is detune the LO slightly so that

Figure 1. HR30 schematic diagram (courtesy of Ramsey Electronics).



the difference IF is some audio tone you can hear. In this case, the received signal is dots and dashes of RF.

The big benefit of a DC or ZIF receiver is its simplicity. Another benefit is that the selectivity is easier to obtain at the original information frequency (audio). Inexpensive RC filters can be used instead of a crystal filter to get the desired selectivity.

Anyway, let's get back to Figure 1. The IC labeled U1 is a NE602 that contains the mixer and a local oscillator circuit. The mixer gets its input from the antenna via a tuned transformer, L1. This circuit gives some initial selectivity. A plain old 10K pot at the antenna serves as an RF gain control.

The local oscillator frequency is set by inductor L2 and capacitors C4 and C14, as well as diode D1. D1 is just an ordinary rectifier diode, reversed biased to act as a varactor or voltage variable capacitor. The reverse bias voltage comes from pot R2 and R5. This pot varies the reverse bias on D1, varying its capacitance. This varies the input frequency tuning of the local oscillator over a range of about 250 kHz to 300 kHz.

The high frequency sum output of the mixer is removed by low pass filter C7 and the resulting recovered signal is fed to the audio power amplifier. This is the popular 386 IC power op-amp. The capacitor, C9, boosts the gain to 50 and a 10K pot, R3, serves as the audio gain control. The amplifier has enough guts to drive a small, 2" speaker, but most CW operators usually prefer headphones. I certainly do.

The whole receiver runs from a 9 volt battery. A 6.2 volt zener stabilizes the mixer/oscillator voltage to give adequate stability. The receiver has an RCA phono plug for an antenna input.

Building the Kit

Constructing a kit is not too difficult. Even though it has been a few years since I was a heavy Heathkit builder, my soldering skills came back to me pretty quickly. If you have never built a kit yourself, you will find this one to be pretty easy; it's a good starter kit, even for the novice hobbyist. My advice as a long-time kit builder is this:

Take your time. If you rush, you will make an error. Read each step of the process twice and double check it after you do it. We are all attuned to our instant gratification way of life, but try to have some patience now, as it will save you much grief, frustration, and overall aggravation later.

Read the directions. What can I say? We all hate to read and we tend to scan over things. If you misread the instructions, you will surely screw up.

Solder carefully. Use a soldering iron with a small tip and a wattage rating of about 25 watts. A 35 watt iron is probably the hottest you should use for this kit to avoid damage to the board and other parts. A 15 watt iron is probably too small, as its heat output is too low.

Double check all of your steps when you have completed the construction. It is still best to take this irritating step if you want to avoid problems later.

A further word about soldering: Use rosin core solder. Also, hold the iron tip at the junction of the PC board copper pad and the component lead and let it heat a few seconds before applying solder. Then let the solder flow at the junction of the iron tip and the two surfaces to be joined.

The key is to balance the heat and the amount of solder. Use as little solder as possible. Just be sure to cover the connection and be sure the solder has fully melted. If it has, the joint will be silvery when cooled. If the joint is dull gray or crinkly looking,

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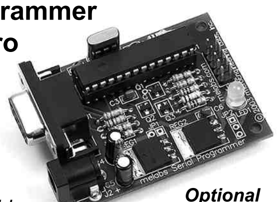
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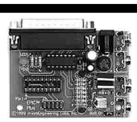
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then you probably have a "cold" solder joint — that means no actual electrical connection. If that is the case, just reheat the joint with the iron for a few seconds. Be ever so careful not to short out adjacent pads with a solder bridge. Be especially watchful when you solder the IC pins.

It took me about three hours to build the whole kit. I am reasonably experienced, so I guess that is a short time. If this is your first time, you could spend several more hours. Don't sweat it. This is not a speed contest and the more you build, the faster you will get.

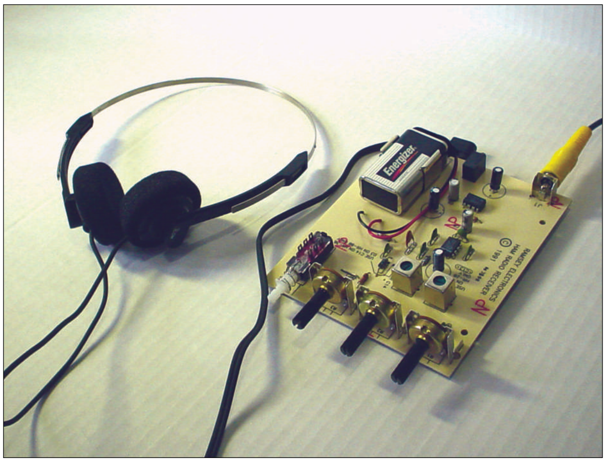

Figure 2. The completed kit.

Testing and Aligning the Receiver

This is the process of checking to see if the receiver is working and then aligning it to the desired frequency range. The ham 30 meter band extends from 10.1 to 10.15 MHz. It is only 50 kHz wide, but that's enough for CW operation. You will need some kind of frequency reference to get the alignment right. You can use an available RF signal generator, a grid dip meter that contains an integral oscillator, or a frequency counter. You can also use the companion QRP30 transmitter if you bought one, as I did. I have an MFJ 269 HF/VHF/UHF SWR analyzer. It contains a signal generator and frequency counter, in addition to an impedance analyzer and SWR meter. If you plan to do much kit building or hamming, this is a great instrument to have on hand.

You will need to connect the battery and a set of headphones or a speaker first. The kit comes with a miniature phone jack and my phones have a larger plug. In fact, all four sets of phones I have use this larger plug. Why Ramsey does not use the standard size, I don't know. I did find the miniature plug at RadioShack and had to install it on my phones — what a nuisance.

You will also need an antenna. I just used a 20 foot piece of #22 hook up wire I had and tack soldered it to the antenna connection on the back of the PC board. I don't know about you, but I always hated to put a connector on a piece of coax. It requires precise dimensional cutting of the inner conductor and braid, then super careful soldering to avoid

Resources

For more information, call or Email these sources for their catalogs.

All Electronics
This is the vendor that had the coax connector adapters.
800-826-5432
www.allelectronics.com

MFJ Enterprises
Lots of ham kits of all kinds.
662-323-5869
www.mfjenterprises.com

Ramsey Electronics
Lots of other kits, in addition to the ham radio stuff.
716-924-4555
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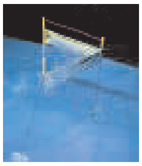

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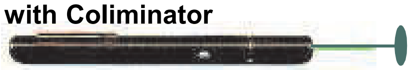

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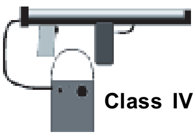

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melting the insulator — a real pain.

If you are going to use a standard dipole or vertical antenna, you will need the coax cable and some connectors. For testing and alignment, the wire is a sufficient antenna. As far as I am concerned, the RCA plug on the receiver is a lousy substitute for a connector. I know a standard SO-239 is more expensive, but it is the better choice and most hams will pay for it.

The alignment procedure is not difficult, but it is tricky. You will need a plastic or other non-metal screwdriver to adjust the cores of L1 and L2. Follow the procedure in the manual.

Figure 2 shows the completed kit. Ramsey actually sells a neat plastic housing for this receiver. The PC board slides into the box and some nice knobs are supplied for the controls. I didn't use this housing, as I guess I like the raw look of the PC board assembly.

Using the Radio

Am I lucky or what? My kit worked the first time and — after alignment — I could hear CW signals on the band. Tuning is very smooth with the pot and the power amp supplies more than enough volume for the headphones. It has taken me a while to regain my code copying skills, but — like riding a bike or playing the guitar — you never forget. You just get rusty. I plan to listen and copy for several weeks to get my skill back.

The Antenna

I did go ahead with a formal dipole antenna, since I will certainly need the best antenna I can get when I set up the QRP transmitter. A dipole for 30 meters is one-half wavelength long. The best material is #12 or #14 copper wire. You can compute the exact length with the familiar formula:

Length in feet=468/f (in MHz)

I used a frequency of 10.1 MHz and got a length of:

Length in feet = 468/10.1=46.34 feet
or 46 feet, 4 inches

Your finished dipole length should be this long, but — before you cut the wire — you need to figure out how you are going to mount it. Normally, you use some glass, ceramic, or plastic insulators at each end that are then attached to the support with small rope. You will need to leave several inches of extra wire on each end to secure the wire to the insulators.

Next, you cut the wire in half. This is where you will connect the coax cable. To make the antenna, I bought an assembly that has an SO-239 UHF type coax jack on an insulator and two wire pigtails. You

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solder one-half of the wire to one pigtail and the other length to the other pigtail. Oh yeah, be sure to scrape the enamel insulation from the wires before soldering so you will actually make a good electrical connection.

As for the transmission line, I bought a 50 foot length of RG-8/X coax cable. This is a fairly light, low cost 50 Ω coax and the attenuation is relatively low, at least at 10 MHz. The cable came with PL-259 connectors already in place, just like I wanted.

One end screwed into the jack on the antenna insulator. The other end, of course, does not fit the RCA coax connector on the receiver. I actually found a coax adapter that converts the PL-259 to an RCA phone plug. I hope Ramsey puts a regular coax connector on any future models. (Note: The more you fool around with the hardware of electronics, the more you realize that a great deal of it involves wires, cables, connectors, and such and what connects to what. In reality, that is what a tech does these days.)

One further word about the coax: The standard dipole has a 75 Ω natural center impedance. You can get a 75 Ω coax, like RG-59/U, but it does not match the transmitter output. I used 50 Ω coax and that does, indeed, produce a mismatch. The standing wave ratio will be about 75/50=1.333. That is not too bad.

Actually, any SWR less than 2 is usually acceptable. Anyway, the mismatch may not be that bad, as the actual center impedance of the dipole depends upon the height above ground. In my case, with the antenna so low, I suspect that I have only a minor mismatch, if any at all. I will find out for sure when I tune up the transmitter.

It has been a while since I put up an antenna. I strung one end about 20 feet up in one of the big oaks in my back yard. I attached the other end to the top of a gazebo on the other side of the yard. It's not exactly the optimum location, but — in a neighborhood with covenants about no antennas — I had to keep it low profile. It remains to be seen how well it will work. For receiving, it should be significantly better than my hook up wire.

It was. There is nothing like a good, resonant antenna. Signal strength seemed much greater. I was copying signals from all over the US and even some foreign signals. I really need to get familiar with all the foreign call prefixes again.

One final word about the antenna: I built my own since I had done it before, but you can buy an antenna kit. RadioShack has one and so does Universal Radio — the company where I bought the antenna insulators, wire, and coax. MFJ Enterprises also sells one. Buying a kit gives you all the parts at one time and some instructions. It is the way to go if it is your first time.

To sum up, a receiver kit and the antenna is a great weekend project. My cars didn't get washed, but I had fun doing something that I had nearly forgotten about. Next, I will build the transmitter kit and try making a contact. I will report on that project in February. **NV**

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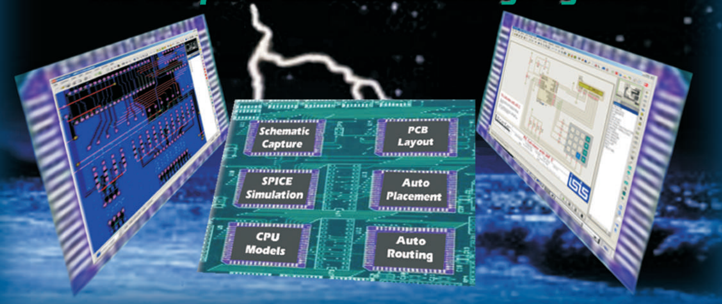

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Personal Robotics

A Look at Robotic Behavior

At the rate I have been adding motors, drivers, and sensors to my projects, I will be in a lot of trouble in only a few years. I have done 12 motored centipedes, 18 jointed hexapods, and I am planning a robotic ecosystem with 30 robots with three motors each. Of course, at some point, this has to stop; I'll need to scale back.

There are perfectly valid reasons for taking a step back and reevaluating what you are doing. It gives you a chance to refocus and look at things in a new light. One area I have been neglecting in my experiments is robotic behavior.

After all, what good is a bunch of wire and motors if it doesn't do anything? Besides, there is a lot of fun to be had in the area of behavioral robotics.

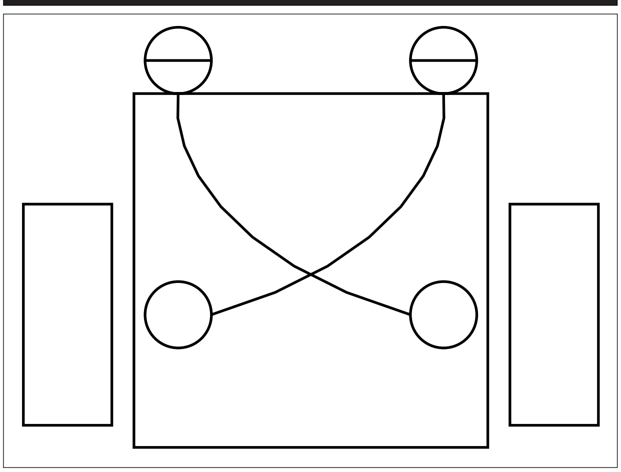
I'm no historian, so I may be wrong on this one, but the earliest experiments in robotics behavior that I am familiar with were carried out in the 1950s by a gentleman named W. Grey Walter. Walter's battery-powered robots used vacuum tubes to provide the simple functionality he imbued his creatures with and, despite their rudimentary circuitry, they exhibited extremely complicated behavior.

Grey's robots — he called them tortoises — make a fascinating platform with a turret and drive wheel powered through slip-rings and two trailing wheels, supporting the bulk of the electronics (much like a child's tricycle). A good starting point for reading about him is **www.plazaearth.com/usr/gasperi/walter.htm**

In the 1980s, a gentleman named Valentino Braitenberg published *Vehicles: Experiments in Synthetic Psychology*. Braitenberg's work has become a sort of bible for making simple behavioral robots. Braitenberg's work relates well to the two motored, differential drive robotics platforms that everyone and his brother seem to be selling. If you are the adventurous sort, you can try a tortoise, but I prefer to go with the differential drive.

The basic concept behind a Braitenberg vehicle is that sensors which are meant to produce a positive stimulus are wired to motors on the opposite side of the body.

Figure 1. A general Braitenberg vehicle layout.



Given this simple model, there are many ways we can experiment with even the simplest of sensors. With more programming, we can take this further into artificial neural networks and other types of AI.

Before we begin programming, we need a platform. You can either buy one or make one. Personally, I prefer building. If you do choose to buy one, there are several platforms available from advertisers in *Nuts & Volts* and *SERVO Magazine* (**www.servomagazine.com**).

If you choose to build your own, I suggest referring back to my column in the July 2004 issue of *Nuts & Volts*.

Here is my bill of materials:

- One piece of Evergreen sheet styrene, #4518 sidewalk tiles
- Two R/C servos — I prefer Futaba S3004 because of the bearings
- Eight 1" standoffs, #2-56 or #4-40, male/female
- One piece of Plastistruct 3/8 square styrene
- One ping pong ball
- One set Tamiya #70111 wheels
- One four-cell AA battery pack
- One Plug-a-Pod development kit
- Two photo resistors
- Three Sharp distance sensors (or more, up to six), your choice of analog out.
  - GP2D120 for close range
  - GP2Y0A21YK for medium
  - GP2Y0A02YK for long
- One 1,000 µF or greater cap rated at 10 V or better
- One 1N4001 diode or similar
- Miscellaneous resistors, solder, glue, wire, etc.

To begin, we need a base to mount our stuff to — a piece of foamcore, a CD case, something built from scratch, or even 1/4" plywood. It really doesn't matter, as long as it doesn't weigh too much.

I made mine with a 4" x 4"

section of Evergreen sidewalk tile with 3/8 square Plastistruct tubing around the perimeter to strengthen it. I also glued single 1/2" squares on the opposite side to act as pads for my standoffs and to add a bit of strength.

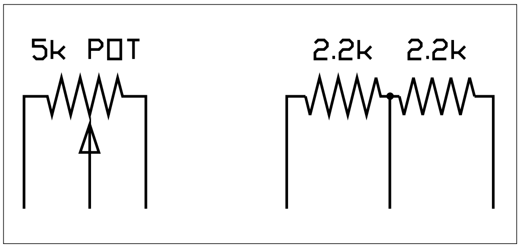


Figure 2. A potentiometer compared to fixed resistors.

Once the glue had set up, I took the PlugaPod development board and screwed sets of standoffs into it — flat, female side down. I then glued the standoffs to the 1/2" squares on the 4" x 4" base I had made.

While the glue is setting up, we can modify the servos for continuous rotation. I think that there must be 500,000 sites on the web that show how to modify servos, but I will give a quick overview, just so you know what you are up against.

There are two modifications that must be performed. We need to modify the mechanics to allow for 360° rotation and we need to provide for a neutral electrical position that the servo works against.

To modify the mechanics, you need to reserve a clean area on your desk and take apart the gearbox. Be careful to keep the order of the gears correct; make a sketch if you need to. You will find a gear with a stop on it. This stop must be removed, usually by simply cutting it with a knife. Be careful not to let the shavings contaminate the gears.

Once the gear is modified, you need to modify or remove the feedback potentiometer. If you choose to modify it, you must decouple it from the output gear. I usually just replace it with two fixed 2.2K resistors and tune the servo in software, but others prefer to leave the adjustable resistor in place and simply shorten the shaft — some even go so far as to put a slot in it.

One of the more elegant modifications I have seen involved being able to slide a screwdriver down the screw-hole for the servo horn to turn the shortened pot shaft. Personally, I feel that anything adjustable can be unadjusted; I would rather put fixed resistors in place and redo software if it ever goes out of tune. Another nicety is to reverse the polarity of one of the motors so the same command polarity produces the same rotation.

Whether you decide to use fixed resistors or an adjustable pot, it is now convenient to be able to run the servos. At this point, build a power buffer for your servo or electronics. The capacitor acts as a small battery and the diode acts as a one way valve. Once you have this circuit, you can run your servos.

I connected the left servo to PWMA0 and the right to PWMA1. The following lines of code will allow you to run the servos:

```
DECIMAL
32767 PWMA0 PWM-PERIOD ( ~13.11 mS
Timebase
       PWMA0 INDEPENDENT

: L PWMA0 PWM-OUT ;
: R PWMA1 PWM-OUT ;
```

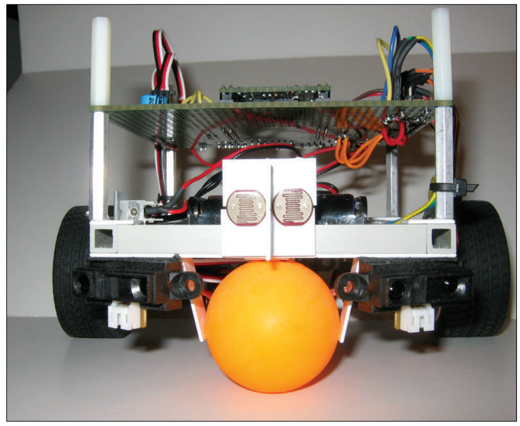


Figure 3. Detail of the base.

Radio control servos take in a PWM signal to command them. The neutral of these servos is 1.5 ms. You command them to neutral by executing the following:

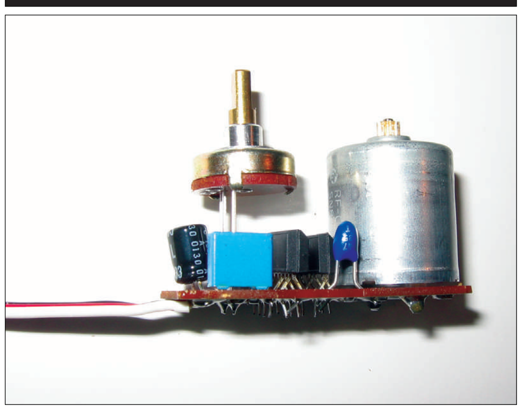
```
7500 L
7500 R
```

If you went with a potentiometer for adjustment, simply turn the pot until there is no motion of the servo. If you went for software tuning, there is a little work cut out for you, but it is good practice.

By trying values higher and lower than 7,500, you can affect a speed and direction change. My experience with a variety of different modified servos indicates that you can expect a range of ±400 from wherever your neutral position is. Start out by finding the neutral position, note that value, and try different speeds that are higher and lower than that until

Figure 4. The gear that needs to be trimmed.

Figure 5. The servo guts, including potentiometer.



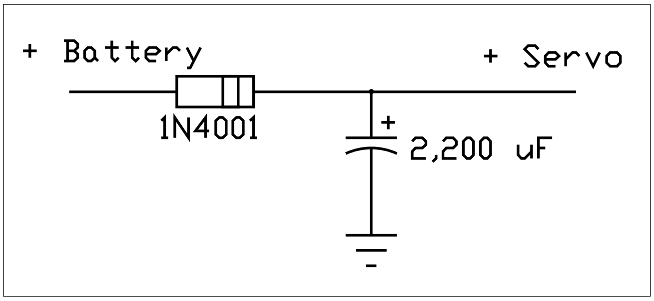


Figure 6. Buffer for servos.

you do not see a speed change. Make a note of these. You will want to take the value that is closer to your neutral position and use that for your difference.

Example: (numbers simplified for readers' sanity)

Neutral	Left	7,500
Forward	Left	7,900
Reverse	Left	7,100
Neutral	Right	7,500
Forward	Right	7,100
Reverse	Right	7,900

The last complicated thing in the mechanical build is the tires. These can be fixed to the six point horn on a Futaba servo horn with some small wood screws or other hardware.

The last thing to do is affix everything to the chassis. I prefer double-sided tape. I pre-solder pigtails to all the sensors and mount them with double-sided foam tape. A ping pong ball glued to the bottom acts as a decent skid. I can run the robot on carpet or linoleum with ease. As long as it is kept light, everything is fine.

This basically concludes the mechanical build. The real purpose here is robot behavior, so we're okay as long as things don't fall apart. It does not need to last forever.

The electronics are relatively straightforward. While we could throw in nice little R/C filters on everything, I didn't bother. My thought was that, since the electronics directly couple to the motors through software effectively, data integrity isn't my real concern here.

I connected the Sharp analog sensors and photo resistors as follows:

ADC0	GP2D12	Right sensor
ADC1	GP2Y0A21YK	Rear sensor
ADC2	GP2D12	Left sensor
ADC3	Photo sensor	Right
ADC4	Photo sensor	Left
ADC5	Available	
ADC6	Available	
ADC7	Available	

The last little bit of hardware voodoo concerns the photo resistors. By using a voltage divider circuit with a fixed resistor on the bottom leg, you can use a good portion of the range of the onboard A/D without having to resort to more exotic circuitry. In my case, I used a 4,700 Ω resistor with a 3.3 V supply. My photo resistor had a range of 50 to 120,000 Ω and, as configured, had an output range of .12 V to 3.26 V.

(3.3*4,700)/(50+4700)=3.26 V
and
(3.3*4,700)/(120,000+4,700)=.12 V

This gives us 95% of the span of the A/D converter, which is plenty.

Once all your sensors are powered and wired, you can start taking readings.

My light sensors gave me the following readings:

Dark	3,585
Light	50

My distance sensors gave me the following readings:

Far	280
Near	2,500

So, where does that leave us? How do we get numbers into servos that have their own range from sensors that output their own range? The answer is to normalize them. For example, if we wanted our darkness sensor to range from 0.0 to 1.0, we need to do some simple math.

Our sensor's span is the maximum reading, minus its minimum reading: 3,585-50=3,535. I like to call

Figure 7. Tire attachment detail.

Figure 8. Tire attachment detail.

this a conversion constant. To normalize a reading, we take a sensor reading, subtract its minimum value from it, and divide by the conversion constant. For example, a reading of 1,817 would be normalized as follows:

(1,817-50)/3,535=0.5

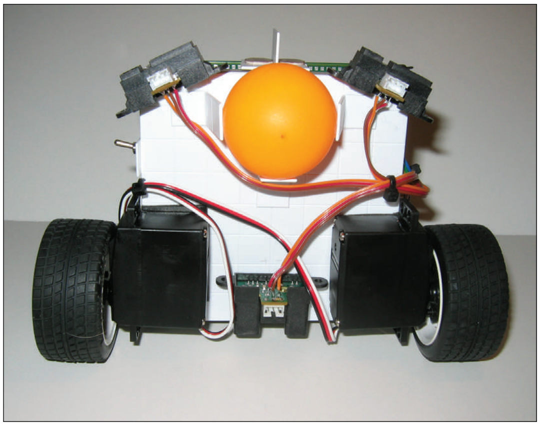


Figure 9. Bottom detail.

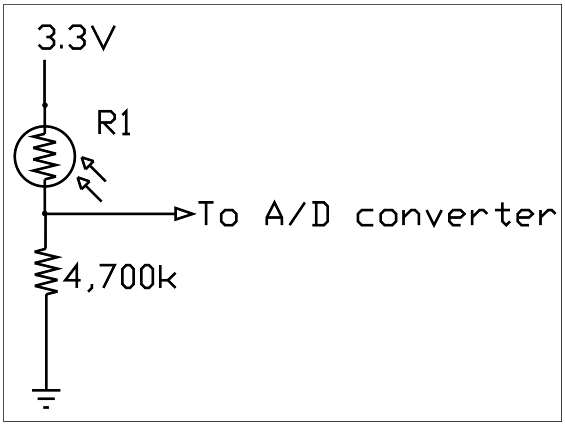


Figure 10. Voltage divider.

Voilà — now we have a darkness sensor. To make that into a lightness sensor, take the sensor's reading from the maximum reading and divide by the span:

(3,585-50)/3,535=1

Cool stuff, huh? This is a really handy method of converting from one measuring system to another. We now have the information to express ourselves in a programming language.

In IsoMax, we can say the following:

```
: RIGHT-DARKNESS
  ADC3 ANALOGIN 8 / S>F ( TAKE A READING, CONVERT TO
FLOAT
  50.0E0 F- 3535.0E0 F/ ( OFFSET THEN SCALE
;

: RIGHT-BRIGHTNESS
  ADC3 ANALOGIN 8 / S>F          ( READ AND CONVERT
  3585.0E0 FSWAP F- 3535.0E0 F/ ( OFFSET AND SCALE
;
```

To see a reading, we can type the phrase:

```
RIGHT-BRIGHTNESS F.
```

We can also apply this scaling and offsetting thing to the servos, as well.

If you recall, I had the following readings for the left servo:

Neutral	7,500
Forward	7,900
Reverse	7,100

Therefore, we have a span of 7,900-7,100=800, but — before we go further — we can play a little trick. Rather than normalizing our servo to 0.0 to 1.0, let's make it from -1.0 to 1.0. In this way, we can command forward rotation with a positive command and backward rotation with a negative command. To do this, we do the following:

Conversion constant=(maximum-minimum)/(maximum input-minimum input) or, in this case, (7,900-7,100)/(1- (-1))=400. We then need to apply this number to our input of -1 to 1 and then offset it, as we did with the light sensor. For example, full forward speed would be:

7,500+(1*400)=7,900

Circle #84 on the Reader Service Card.

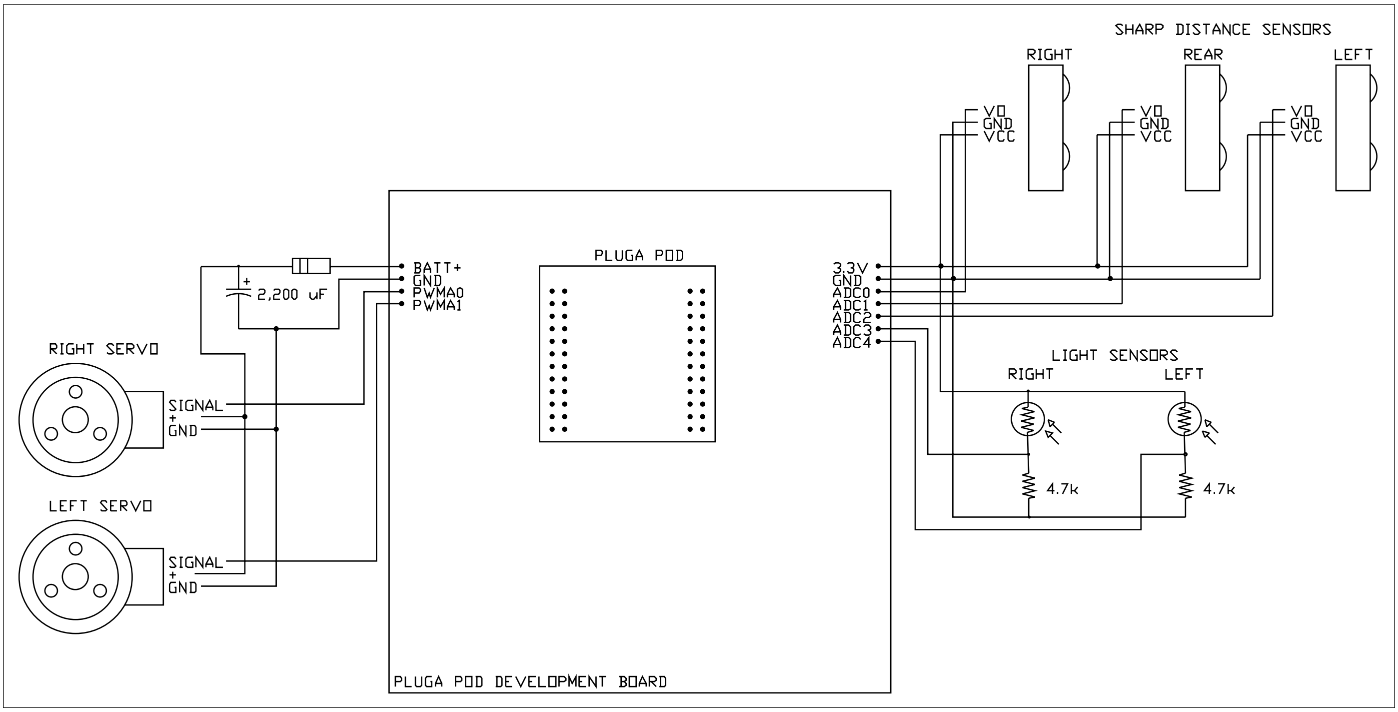


Figure 11. Overall schematic.

Half speed reverse would be:

7,500+(-.5*400)=7,300

For the motor on the opposite side — which is running in reverse — we can simply subtract the scaled input rather than add it.

Neutral	7,500
Forward	7,100
Reverse	7,900

7,500-(1*400)=7,100 or our full forward command speed.

The IsoMax code to command a motor then becomes something like:

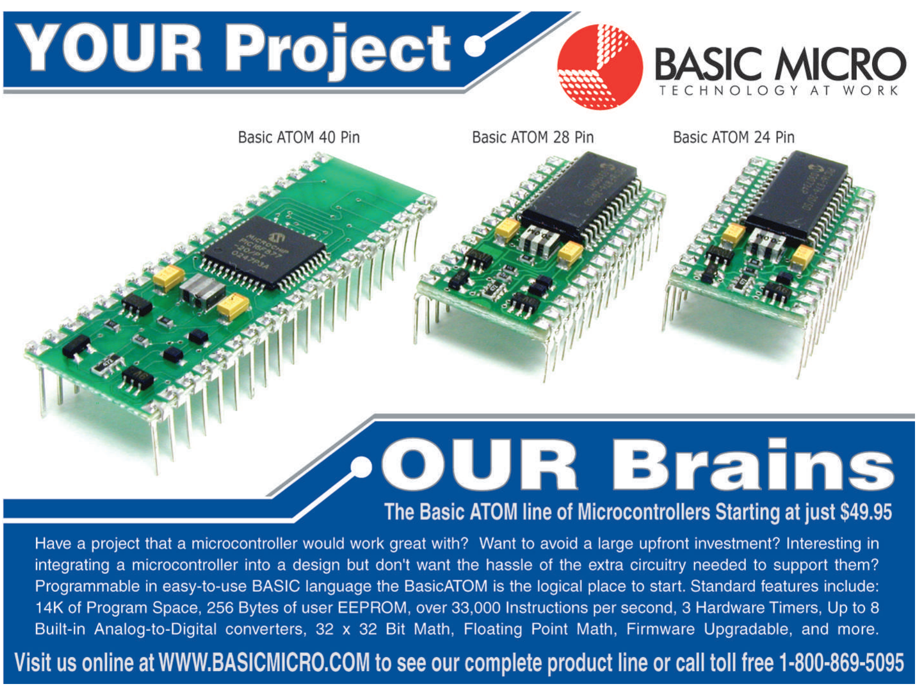
```
: RIGHT-MOTOR
  400.0E0 F* 7500.0E0 FSWAP F-   (
CONVERT AND OFFSET
  F>D DROP PWMA1 PWM-OUT          (
CONVERT TO SINGLE AND OUTPUT
;

: LEFT-MOTOR
  400.0E0 F* 7500.0E0 F+          (
CONVERT AND OFFSET
  F>D DROP PWMA1 PWM-OUT          (
CONVERT TO SINGLE AND OUTPUT
;
```

Now, we have the essential elements of what is called a Type 2 Braitenberg vehicle. To fill in the picture a little more, we can add the front two distance sensors to the mix.

Far	280
Near	2,500

So, a nearness sensor's conversion would have a conversion constant of (2,500-280)=2,200. To get a nearness reading, we take (Input-280)/2,200 to get a value of 0.0 to 1.0, proportional to nearness. To sum things up, we have the tools we need to play with simple behaviors, as described by Braitenberg. We have light sensors that give us readings that cause a positive stimulus



and distance sensors that cause a negative stimulus. The basic concept here is to take and sum the stimuli to the motors. For example, imagine wiring up the distance sensors to subtract from the motors and the brightness to add to the motors. This would cause an object-avoidance behavior.

By playing with the various strengths of inputs, we could program a behavior that would cause the robot to desire certain environments. Think on this for a moment: Imagine we have the right light sensor wired to the left motor and the left light sensor wired to the right motor. This will cause a light-seeking behavior. In essence, a behavior can be expressed as simply as:

```
: LIGHT-LOVER
  RIGHT-BRIGHTNESS LEFT-MOTOR
  LEFT-BRIGHTNESS  RIGHT-MOTOR
;
```

This alone will cause a creature to seek light. It may turn out, however, that low light values will produce very little motion. We can tweak things a little by scaling and offsetting yet again. By dividing the light value by 2 and adding it to 0.5, our light now never falls below 0.5.

```
: LIGHT-LOVER
  RIGHT-BRIGHTNESS 2.0E0 F/ 0.5E0 F+
LEFT-MOTOR
  LEFT-BRIGHTNESS  2.0E0 F/ 0.5E0 F+
RIGHT-MOTOR
;
```

Another interesting technique is to make a response that is non-linear. For example, suppose you wanted your creature to be attracted to medium light levels, but not darkness or extreme brightness. The following formula would produce a "hump" in the middle of the response:

OUT=SIN(pi/INPUT)

Or, expressed in IsoMax:

```
: MAKE-HUMP
  PI FSWAP F/ FSIN
;
```

The possibilities are endless. Different sensors can be wired to different actuators as either positive stimuli or as retarders. It really is worth picking up Braitenberg's book; it covers a lot of interesting topics without a bunch of deep, unpleasant math. Combine the concepts in that book with the source code I have provided online (**www.nutsvolts.com**) and you have a simple starting point for experimenting with behavioral robotics. **NV**

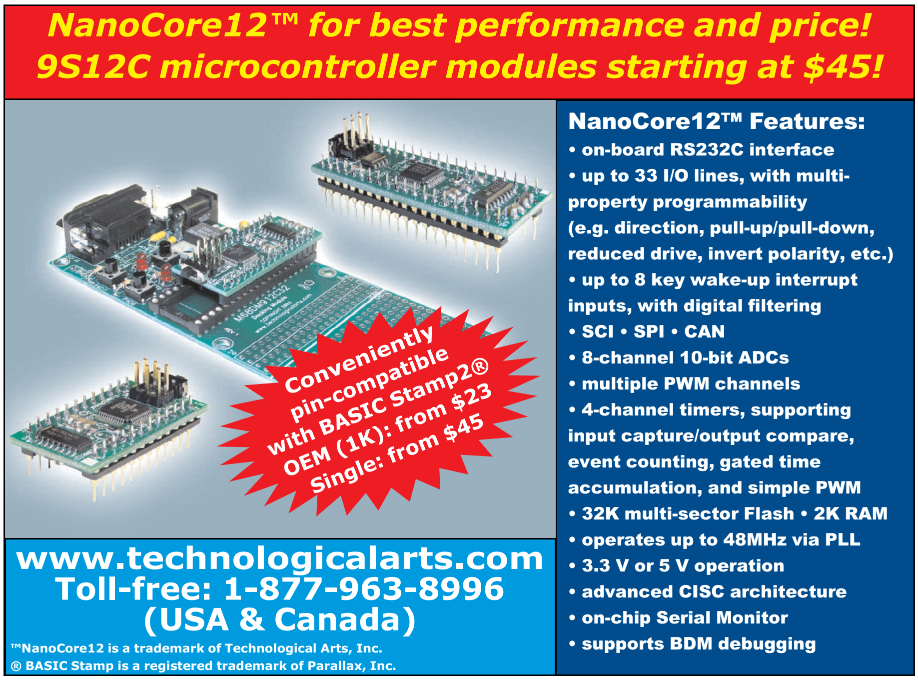
Web Links

www.plazaearth.com/usr/gasperi/walter.htm

www.frc.ri.cmu.edu/~hpm/book98/fig.ch2/Elsie.150.jpg

www.dprg.org/projects/2003-05a/

www.nyx.net/~jpurbric/



Tech Forum

QUESTIONS

I have a small sports car and want to install an amplifier for the subwoofer. Unfortunately, none of the commercially available units are small enough to fit in the available space. Since I don't need all that much power, can you suggest a design that could be made fairly compact?

#12041 **Tom Smith via Internet**

I am trying to either purchase or build a low-cost, digital color temperature measurement tool. I read the article in *Nuts & Volts* about a color sensor and thought perhaps the same components could be used for my project but, I don't know.

I want an instrument that will accurately measure and display the color temperature of a specific type of light bulb. The bulbs are rated to a color temperature but need to be verified. The temperature range needs to be between 2,000° and 7,500° Kelvin. Any assistance or direction would be greatly appreciated.

#12042 **Jay Watson via Internet**

I need a small, narrow band, FM transmitter in the 217 MHz band, which is reserved for hearing aids. I'm trying to connect a directional microphone to my hearing aid receiver. There must be a manufacturer who makes a small PCB for this — or a kit. Or maybe there is a single chip that does the job?

Phonak and other companies have such transmitters in their product offerings, but their package comes at a horrendous price. Does anyone have any ideas? I have only one good ear, and directionality is a great assist!

#12043 **Dick Lagerstrom, Mountain View, CA**

Can anyone come up with an inexpensive circuit (perhaps just using a strain cell?) that I can use to check the electric impact wrench in my home hobby shop?

#12044 **Ervin Sly Nipomo, CA**

I am looking for a simple circuit to amplify or intensify the ring current on a phone line. I want to ring more than four phones at once on a single line. The current supplied by the phone company is not adequate to ring more than two or so. Is there a simple circuit to increase the ring current without reflecting back on the phone company's lines?

#12045 **Charlie Wineman via Internet**

Many years ago, I used an IC from Holtek that, with very little external circuitry, would play different melodys. The IC was in a TO-92 package looking much like a transistor. One I remember played "We wish you a Merry Christmas" and the part number was HT-3813E. Holtek has discontinued making this IC. Does anyone know of any other manufacturers that make a similar IC or is there a way to program a microcontroller to serve the same purpose?

#12046 **Tim Fitzstephens Kalamazoo, MI**

I would like to make a PC keyboard emulator, where toggling a switch could emulate everything from an "A" keypress to a "Ctrl+Alt+Shift+A". A schematic would be great,

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ANSWER INFO

• Include the question number that appears directly below the question you are responding to.
• Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
• Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
• Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

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All questions should relate to one or more of the following:
1) Circuit Design
2) Electronic Theory
3) Problem Solving
4) Other Similar Topics

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• No questions will be accepted that offer equipment for sale or equipment wanted to buy.
• Selected questions will be printed one time on a space available basis.
• Questions may be subject to editing.

Helpful Hints

• Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
• Write legibly (or type). If we can't read it, we'll throw it away.
• Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

but even a nudge in the right direction is appreciated.

#12047 **Frank Mozingo**
via Internet

I run a 5 HP, single phase air compressor in my shop due to the fact that I have to synthesize my own three-phase current. On the advice of a repairman, I had an electronic module installed on the motor to replace the starting contacts, which were burning out every six months or so. Since then, I've had to replace the module at least twice, which involves removing the motor from the compressor and taking it to a service facility 50 miles away. This costs me about $200.00 to $300.00, as well as several days of a near shut-down condition. What, exactly, is this expensive module about, and can I replace it myself? If so, where can I get one? Would I be money ahead to just go back to conventional contacts and figure to replace those every six months?

#12048 **Fred Howe**
Owego, NY

ANSWERS

[10042 - September 2004]

When the BePC came out about 10 years ago (remember those?), there were two vertical columns of LEDs on its front panel. One lit to show CPU activity level; the other showed (I believe) memory activity. I'd like to make something like that for my PC and I wonder what would drive the meters?

I seem to remember an Internet project a few years back for adding a "tachometer" to a PC, via an automotive needle/meter tach.

I found the PC Tachometer on sale for $38.00 at **http://store.yahoo.com/xoxide/pctachometer1.html** It would be a straightforward matter to replace the tachometer meter movement with a LED bargraph if you'd prefer that type of display, using one or more LM3914 bargraph drivers. Note you'll probably need the circuitry from the internals of the tachometer in addition to the included software. Both are well worth the price of the "tachometer" kit.

If you'd prefer a more sophisticated display, check out those available from Matrix Orbital (**www.matrixorbital.com**). You'll have to roll your own software, but there are several examples of their displays being used by case modders for CPU bargraphs, so perhaps you'll find something already written on the Internet.

George Scott
Alexandria, VA

[10044- September 2004]

I have a 35" Sony TV with PIP. Is there any way to add (build or buy) progressive scan to the TV so it can use the enhanced output from a DVD player?

In short, no. There is no way to add progressive scan externally to an existing interlaced-only TV. Unfortunately, you need to purchase an HDTV or monitor to get this capablilty.

George Scott
Alexandria, VA

[10043- September 2004]

I have a vacuum pump that uses four D cells in series for a total of 6 VDC. I want to build or acquire a battery eliminator for the pump. How do I determine the amps required for the pump? The unit has a PCB with an NEC D882P.

#1 Any device with four D cell batteries in series to provide 6 volts is, by nature of the batteries involved, designed to use well under 1.5 amps of current. You can connect an ammeter in series with one end of the battery pack and the terminal the battery touched, and measure the

Circle #127 on the Reader Service Card.

actual current used. The D882P device is limited to 4 amps and, in typical use, a device is not run at its full capability. Therefore, any battery eliminator rated about 2 amps would work fine and not be overloaded. RadioShack sells such power supplies, as do many other electronic distributors.

Erik von Seggern
via Internet

#2 I'm not sure what circuit he has, but, we are happy to provide the datasheet for the transistor that he indicates "2SD882P." In general, feel free to forward any requests for NEC datasheets to this email: **support@necelam.com**. We have access to a huge internal database of NEC devices that can usually find a match.

Tom Wolf
NEC Electronics America
Technical Support

[8046- August 2004]

I cannot seem to find any good information on IR filters for video cameras; for example, I don't know if they come in different densities, strengths, or colors. Can someone write a brief explanation for me?

#1 Here are some general facts about IR filters for both film and video use.

An IR filter is designed to eliminate light in the visible spectrum, and pass only infrared light to the camera. They come with various pass characteristics, depending on the desired use. A simple deep red filter will actually block much visible light, and work fairly well on B&W video cameras and film. However, for true IR only response, you'll want a specialized filter. Manufacturers like Kodak and Hoya make several different types. I've listed Kodak filters here, along with their IR pass wavelengths. Note that the longer the wavelength, the less visible light they pass. An 89B will look very, very dark red if held in front of a bright white light, but an 87C will look practically opaque. How a filter works with a particular camera depends on its chip's inherent IR sensitivity. You should start with something in the 700nm range, which will probably work for most cameras quite well.

Note that most color video cameras, camcorders, and digital cameras include IR blocking filters that reduce their IR sensitivity to prevent IR from contaminating their color representation. However, their IR blocking filters are not perfect, and you can often get interesting pictures from them with IR pass filters in bright sunlight. B&W video cameras usually do not include these blocking filters, so they work quite well under even dim light conditions.

Kodak Wratten IR filter types:

Wratten 25 600nm (deep red)
Wratten 89B (R72) 720nm
Wratten 88A 750nm
Wratten 87 800nm
Wratten 87C 860nm

Filters come in two basic materials: glass and gelatin. The glass filters can get expensive, but gelatin filters are more fragile and require a filter holder. IR filters are sold at most professional photographic suppliers, like B&H Photo in New York (**www.bhphoto.com**), Samy's Camera in Los Angeles (**www.samys.com**), and many shops in major cities. But one interesting source for IR filters — if you just want to experiment — is American Science and Surplus (**www.sciplus.com**). Though not always listed on their website, I've picked up several 4 inch round plastic IR filters there, and while not as good as an 87C, they work quite well, and only cost a few dollars each. You could even cut them to size, if you desire.

Another interesting application of IR filters is to use them to filter a light source. Try an 87 filter over a flashlight, then look at what you get on your B&W video camera. You won't see much light with your eyes, but your camera will show a very bright flashlight spot.

Jim Addie
La Grange Park, IL

#2 Edmund Scientific's Optics website contains specifics for the different lenses, color spectrum, different uses, etc. They can be found at **www.edmundoptics.com**

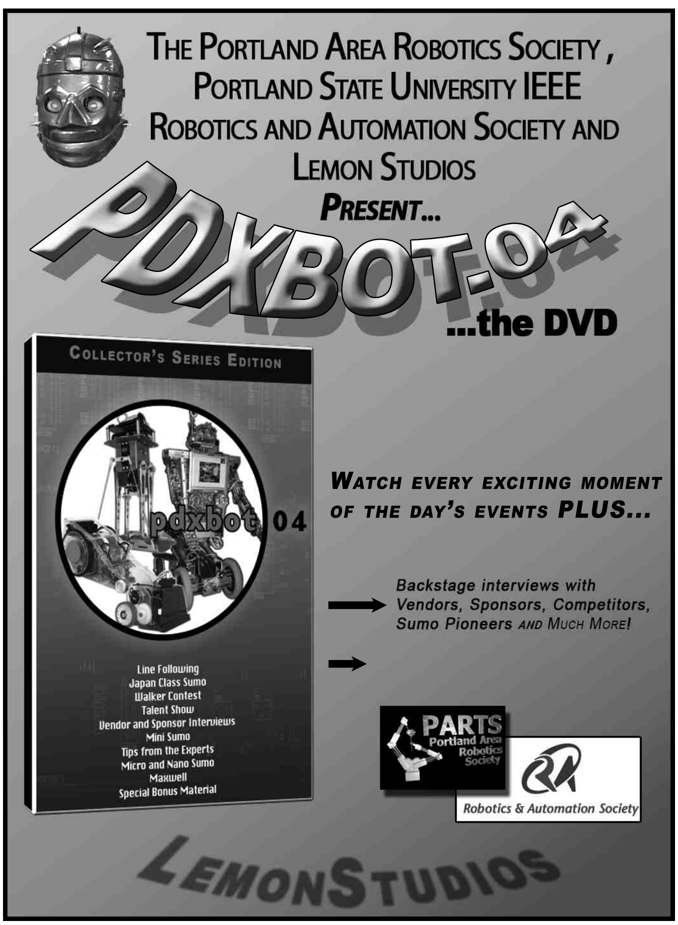
Mark Cecil
Madison, AL

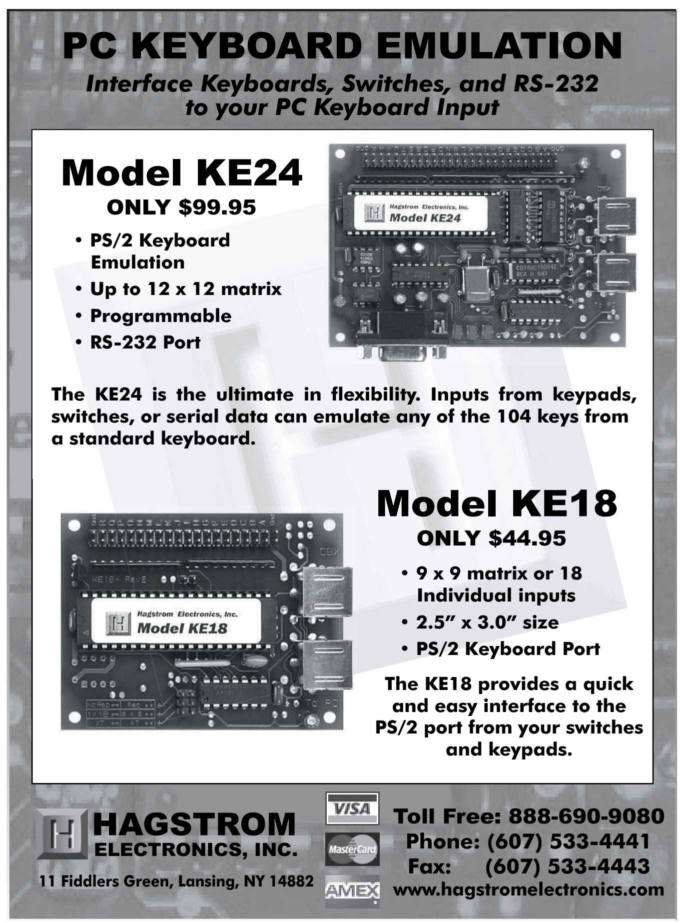
#3 There are three standard Wratten IR filters: #87, 88A, and 9B. The 87 is the darkest, and appears nearly black. This is the best one. The others are lighter. A cheap IR filter can be made from a piece of fogged, developed 35mm color negative film. At your local one-hour photo shop, ask for some scraps of fogged film they cut off the ends of processed negatives. The fogged film filters out most visible light, and pieces can be stacked to make a darker filter. Professional Wratten filters can be purchased in the $13.00 range from Harrison & Harrison, 1835 Thunderbolt Drive, Unit E, Porterville, CA 93257; 559-782-0121. Hope this proves helpful.

Mervin E. Fulton
Tulare, CA

[8042- August 2004]

I need a circuit to transmit and receive a laser signal to detect small, non-moving objects over 100-150 yards away from a portable power supply. The circuit should be able





Circle #134 on the Reader Service Card.

to determine the range to the object and display it during daylight periods. Also, the circuit should be able to discriminate the object from its surroundings, either by applying special reflective coatings to the objects or by making the objects relatively bright as compared to surrounding objects. Is there any circuitry that uses available microcontrollers or discrete components?

While I don't have any circuitry I can point you to, one of the most clever ideas I've seen in recent years uses a laser that turns itself on and off as it receives its reflected signal. The distance is inversely proprotional to the oscillation frequency and can be measured with a simple frequency counter. Let me elaborate a bit.

Initially, assume that the laser turns on at time t=0, and there is no reflected signal at the receiver colocated with the laser. After a time t1=2x/c, where x is the distance to the object and c is the speed of light, the leading edge of the laser "pulse" hits the photodiode, triggering circuitry that turns the laser off. As long as laser light is hitting the photodiode, the laser remains off.

When the leading edge of the laser pulse hits the photodiode, the trailing edge is just leaving the laser. The trailing edge will hit the photodiode also t1=2x/c after it leaves the laser, and the arrival of the trailing edge at the photodiode (and hence the laser light stops) triggers the laser BACK ON! This oscillation continues ad infinitum as long as the laser is lined up with the target. The frequency of oscillation is f=1/[(2x/c) + (2x/c) + td], where td is the propagation delay of the turn on/turn off circuitry. Measure this frequency and you have the distance.

As an example, assume the target is 100 yards away (300 feet). For simplicity, assume light travels at 1 foot per nanosecond. Therefore (neglecting for the moment the propagation delay td), the frequency of oscillation is about (1/600 nsec)~ 1.666 MHz, easily measureable with almost any frequency counter.

To measure the propagation delay, simply place the target at a precisely known distance, measure the frequency, and solve for td.

Of course, I've oversimplified things here, and the devil is in the details. For example, in an outdoor environment, the propagation delay may vary with temperature. Similarly, you will probably need a retroreflector on the target and some kind of collimating optics on the transmitter, along with collecting optics on the receiver, probably with some laser line spectral filtering. But you get the basic idea.

Steve Bepko
via Internet

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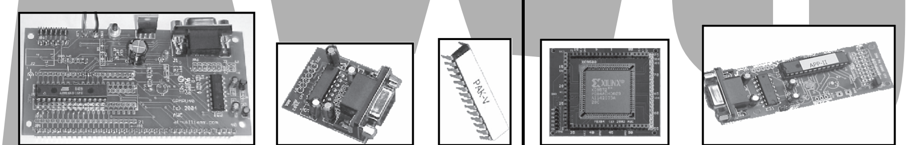

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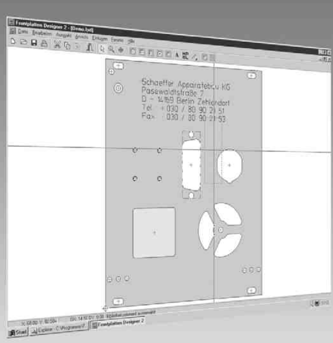

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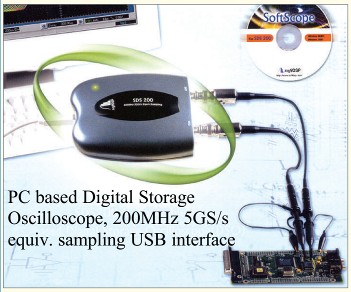

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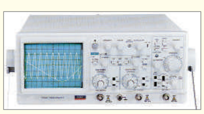


Brand New Not Refurbished! Includes 2 scope probes

A $975.00 Value!

100MHz only *$499.00*

While Supplies Last!

Item# 6510

Details at Web Site > Test Equipment > Oscilloscopes/Outstanding Prices

Hot Air Gun w/Digital Display for SMD's

Now, precise temperature and airflow control is at your finger tips with this digitally controlled Hot Air Gun. Quickly solder and de-solder DIP, BGA and SMT electronic components. Plus, be able to shrink, "Heat shrink tubing".

Details at Web Site Item# CSIHOTGUN-2 $89.00

> Soldering Equipment & Supplies > Soldering Irons

Dual Output DC Bench Power Supplies

As Low As $93.00!

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit and current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance and long life.

NEW!

- Source Effect: $5x10^{-4}$=2mV
- Load Effect: $5x10^{-4}$=2mV
- Ripple Coefficient:: <250uV
- Stepped Current: 30mA +/- 1mA

HOT ITEM!

*Both Models have a **1A/5VDC Fixed Output** on the rear panel*

CSI3003X-5: 0-30v/0-3amp/1-4..$97.00/5+..$93.00
CSI5003X-5: 0-50v/0-3amp/1-4..$107.00/5+..$103.00

Details at Web Site > Test Equipment > Power Supplies

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210
800-528-1417 / 480-464-2485 / FAX: 480-464-5824

Circle #105 on the Reader Service Card.

3M™ DataCom Cable Tester

UNBEATABLE PRICE

Limited Time Offer

This unit allows for mapping, testing and troubleshooting of various lines, including installed data communications, phone wiring and coaxial cable runs. Performs multiple test on the following cable types, up to 1000 feet in length: Unshielded telephone cables with RJ-11 and RJ-45 connectors; Ethernet 10 (100) Base-T; Token Ring; EIA/TIA-568 A/B; AT&T 258a; USOC; 50 or 75 ohm Coax with F or BNC connectors.

Only $49.00

Item# DT-2000

Details at Web Site

Includes: Holster, Case, 7 Remotes & Telecom Alligator Clips

> Test Equipment > Specialty Test Equipment

RF Field Strength Analyzer

Compare at Over $2000!

New Fantastic Low Price: $1299.00!

The **3201** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2060MHz. The 3201 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones, Cordless phones, paging systems, cable & Satellite TV as well as antenna installations. May also be used to locate hidden cameras using RF transmissions

- WFM/NFM/AM/SSB modulated signals may be measured.
- Signal Levels up to 160Channels can be displayed simulaneously on the LCD
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- LED Backlight LCD (192x192 dots)
- All fuctions are menu selected.
- RS232C with software for PC & printer interface
- Built-in speaker

(Includes Antenna)

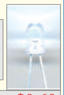
Limited Time Offer

Item# 3201

Details at Web Site > Test Equipment > RF Test Equipment

BAG of LEDs DEAL

Normal brightness LEDs now available in RED, GREEN or YELLOW in 3mm or 5mm sizes. Your choice. *Each bag* contains 100 of the *same* LEDs.



BAG-RED3MM............$1.50	BAG-RED5MM............$1.50
BAG-GREEN3MM.......$1.50	BAG-GREEN5MM......$1.50
BAG-YELLOW3MM...$2.00	BAG-YELLOW5MM...$2.00

Super Bright LEDs Deal:

53B3SCS08...5mm	Blue	SB LED(1500max MCD)	1+ $0.70 /10+ $0.65 /100+ $0.60
5G3UTB-2... 5mm	Green	SB LED(1100max MCD)	1+ $0.45 /10+ $0.35 /100+ $0.30
5R3UT-2/R...5mm	Red	SB LED(3500max MCD)	1+ $0.25 /10+ $0.20 /100+ $0.15
53BW3SCC08..5mm	White	SB LED(3500max MCD)	1+ $1.69 /10+ $1.49 /100+ $1.18
5Y3STC-2......5mm	Yellow	SB LED(3500max MCD)	1+ $0.25 /10+ $0.20 /100+ $0.15

Details at Web Site > Semiconductor Devices > LEDs, Displays & Lamps

FC5001 2 Way FM Radio Tester/ FC6002 Radio Frequency Tracer

The **FC5001** 2-way FM radio tester has the ability to lock automatically and almost instantly on to any FM signal within its frequency range. The **FC6002** radio frequency tracer is useful in locating stuck transmitters or bugging devices in a room or automobile. It excels at silent detecting RF signals for RF security and counter-surveillance applications.

FC5001: $99.00 < RF Security > **FC6002: $149.00**

Details at Web Site > Test Equipment > RF Test Equipment

SONY Super HAD CCD™
equipped camera's feature dramatically improved light sensitivity

SONY Super HAD CCD Color Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Built-in Lens: 4.3mm
- S/N Ratio: > 48dB (AGC OFF)
- Min. Illumination: 0Lux

1-4:$94.50 5+:$89.00

Item# VC-819D

Details at Web Site

> Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

SONY Super HAD CCD Color Camera

Item# VC-805 1-4:$78.50 5+:$75.00

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Lens: 3.6mm
- S/N Ratio: > 48dB
- Min. Illumination: 1Lux/F1.2

Unbelievable Price!

Details at Web Site

> Miniature Cameras(Board,Bullit,Mini's)

SONY Super HAD CCD Mini B/W Board Camera

Item# VC-103

- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV Lines
- Lens: 3.6mm/92° Angle of View
- Min. Illumination: .05Lux/F1.2

1-4:$39.00 5+:$35.00

Details at Web Site

> Miniature Cameras

SONY Super HAD CCD Color Weatherproof IR Cameras

480 TV Lines Resolution

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 480TV lines
- Built-in Lens: 6mm/F1.5
- S/N Ratio: > 48dB
- Min. Illumination: 0Lux

Item# VC-827D

1-4:$159.00 5+:$153.00

Details at Web Site

> Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

NEW!

SONY Super HAD CCD Mini Color Pinhole Camera

- Signal System: NTSC
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Lens: 3.8mm/F2.0 Pinhole/90° Angle of View
- S/N Ratio: > 48dB
- Min. Illumination: 0.8Lux/F1.2

Item# VC-8063CP 1-4:$79.95 5+:$74.95

Details at Web Site > Miniature Cameras(Board,Bullit,Mini's)

SONY Super HAD CCD B/W Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Built-in Lens: 6mm/F1.5
- S/N Ratio: > 48dB
- Min. Illumination: 0Lux

1-4:$84.50 5+:$79.00 Item# VC-317D

Details at Web Site

> Miniature Cameras(Board,Bullit,Mini's)

SONY Super HAD CCD Mini Color Camera

- Signal System: NTSC
- Image Sensor: 1/4" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Lens: 3.6mm/92° Angle of View
- S/N Ratio: > 48dB
- Min. Illumination: 1.0Lux/F1.2
- White Balance: Auto tracking

Item# VC-806B

1-4:$77.00 5+:$73.00

Details at Web Site > Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.CircuitSpecialists.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors, miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handleing items, hand tools for electronics, breadboards, trainers, programmers & much much more! *Some Deals you won't believe!*

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FREE BASIC COMPILER

Program the SX microcontroller in BASIC!

Parallax has just made programming one of the world's fastest microcontrollers even easier by creating a BASIC compiler called SX/B. This FREE compiler is fully integrated into the SX-Key IDE. SX/B was designed to expedite the programming of the SX18/20/28 by providing a simple, yet robust high-level language for the 50 MIPS 8-bit SX microcontroller. SX/B supports in-line assembly language and has BASIC commands familiar to our customers. Ideal for hobbyists, students, and engineers.

To program the SX chip, you'll need the Parallax SX Tech Tool Kit - Plus (#45180 - $129). The SX Tech Tool Kit includes the SX-Key programmer/debugger tool, the SX Tech Board, manuals and 2 SX chips.

To learn more about SX/B visit www.parallax.com/sx and download *Exploring the SX Microcontroller with Assembly and BASIC Programming*, the SX-Key IDE and SX/B On-Line Help files or visit our SX/B discussion forum at http://forums.parallax.com.

While supplies last, we also have the Boe-Bot Serial Line Follower Kit. With this open-sourced SX/B application, you will see how we have programmed the SX28AC/DP to be a co-processor to the Boe-Bot robot (#45203- $35.00).

SX Tech Tool Kit - Plus; #45180; $129

WWW.PARALLAX.COM/SX

Order online at www.parallax.com/sx or call the Parallax Sales Department toll-free at 888-512-1024 (Monday-Friday, 7 a.m. to 5 p.m., PT)

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